Symposium From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication (SYPC)

jointly organized by
the Quantum Optics and Photonics Division (Q) and
the Atomic Physics Division (A)

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Overview of Invited Talks and Sessions

(lecture room V47.01)

Invited Talks

SYPC 1.1	Thu	10:30–11:00	V47.01	**Quantum Communication: real-world applications and academic research** — •Nicolas Gisin
SYPC 1.2	Thu	11:00–11:30	V47.01	**Trapping and Interfacing Cold Neutral Atoms Using Optical Nanofibers** — •Arno Rauschenbeutel
SYPC 2.1	Thu	14:00–14:30	V47.01	**Coherent population trapping in quantum dot molecules** — Katharina Weiss, Jeroen Elzerman, •Atac Imamoglu
SYPC 2.2	Thu	14:30–15:00	V47.01	**Nanophotonic Interconnection Networks for Performance-Energy Optimized Computing** — •Keren Bergman

Sessions

SYPC 1.1–1.6	Thu	10:30–12:30	V47.01	**From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication 1**
SYPC 2.1–2.6	Thu	14:00–16:00	V47.01	**From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication 2**
SYPC 3.1–3.8	Fri	10:30–12:30	V47.02	**From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication 3**

SYPC 1: From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication 1

Time: Thursday 10:30–12:30 Location: V47.01

Invited Talk SYPC 1.1 Thu 10:30 V47.01

Quantum Communication: real-world applications and academic research — •Nicolas Gisin — GAP, University of geneva

Quantum communication is the art of transferring a quantum state from one place, Alice, to another, Zeus. The simplest technique consists in merely sending a system carrying the quantum state, typically a photon, directly from Alice to Zeus. This is basically the way commercial quantum key distribution apparatuses work today, though direct communication is definitively limited to a few hundreds of km due to losses in optical fibers. But there are more sophisticated ways to realize quantum communication, each more fascinating than the other. First, one could exploit 2-photon entanglement and their EPR-like correlations. Next, one could perform quantum teleportation, a mind-boggling 3-photon process. All these have been demonstrated in and outside labs. But the real grand challenge for quantum communication is much more ambitious and fascinating: teleport a quantum state along a chain of sections: from A to B, then from B to C and so on until Y to Z. Moreover, in order to outperform direct communication, the process should be efficient. This requires that the A-B and B-C and * Y-Z entanglements necessary for quantum teleportation, must all be ready before one starts the teleportation processes. This, in turn, implies that the entanglement must be in-between quantum memories located at each node A, B, C, etc, able to hold the quantum state for ms.

Invited Talk SYPC 1.2 Thu 11:00 V47.01

Trapping and Interfacing Cold Neutral Atoms Using Optical Nanofibers — •Arno Rauschenbeutel — Vienna Center for Quantum Science and Technology, TU Wien–Atominstitut, Stadionallee 2, 1020 Wien, Austria

We have recently demonstrated a new experimental platform for trapping and optically interfacing laser-cooled cesium atoms [1]. The scheme uses a two-color evanescent field surrounding an optical nanofiber to localize the atoms in a one-dimensional optical lattice 200 nm above the nanofiber surface. At the same time, the atoms are efficiently interrogated with light which is sent through the nanofiber. Remarkably, an ensemble of 2000 trapped atoms yields an optical depth of up to 30, equivalent to 1.5 % absorbance per atom. Moreover, when dispersively interfacing the atoms, we observe $\sim$ 1 mrad phase shift per atom at a detuning of six times the natural linewidth [2].

Our technique provides unprecedented ease of access for the coherent optical manipulation of trapped neutral atoms and opens the route towards the direct integration of atomic ensembles into fiber networks, an important prerequisite for large scale quantum communication. Moreover, our nanofiber trap is ideally suited to the realization of hybrid quantum systems combining atoms with solid state quantum devices.

Financial support by the ESF (EURYI Award), the FWF (Vienna Doctoral Program CoQuS), and the Volkswagen Foundation (Lichtenberg Professorship) is gratefully acknowledged.

[1] E. Vetsch *et al.*, Phys. Rev. Lett. **104**, 203603 (2010).
[2] S. T. Dawkins *et al.*, Phys. Rev. Lett. **107**, 243601 (2011).

SYPC 1.3 Thu 11:30 V47.01

Quantum networking with time-bin encoded qubits, qutrits and qquads using single photons from an atom-cavity system — Peter B. R. Nisbet-Jones, Jerome Dilley, Oliver Barter, •Annemarie Holleczek, and Axel Kuhn — Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU

We report on the production of time-bin encoded qubits, qutrits and qquads which are one fundamental building block in quantum information processing, networking and cryptography. They are produced by full coherent control of the single-photon generation in a strongly coupled atom-cavity system. This allows for the preparation of single photons in an n-time-bin superposition state with arbitrarily defined amplitudes and phases. The qubits', qutrits' and qquads' properties are determined and demonstrated with the help of a small linear optics quantum network [1].

[1] P. B. R. Nisbet-Jones, et al., "Quantum networking with time-bin encoded qubits, qutrits and qquads using single photons from an atom-cavity system," *in preparation* (2011).

SYPC 1.4 Thu 11:45 V47.01

Highly efficient, fibre-integrated single photon to single mode coupling - based on defect centres in nanodiamonds — •Tim Schröder[1], Masazumi Fujiwara[2], Tetsuya Noda[2], Hong-Quan Zhao[2], Oliver Benson[1], and Shigeki Takeuchi[2] — [1]Nano-Optics, Humboldt University — [2]RIES, Hokkaido University, Japan

Recently, the most direct approach to fabricate a reliable single photon source, by mounting a single quantum emitter on an optical fibre, was demonstrated*. A nanodiamond containing a single nitrogen vacancy (NV) centre was placed on the fibre facet. Such a system easily integrates into fibre optic networks for quantum cryptography and is promising for quantum metrology applications.

Here, we present a tapered fibre based single photon system that has an even wider application range. Single nanodiamonds containing NV centres are deposited on such a tapered fibre of 273 nm in diameter. The tapered fibres were fabricated from standard single mode fibres. For the deposition on the taper, a dip-coating technique was developed, that enables controlled deposition of nanodiamonds and other nanoparticles. For a single NV centre, 689 kcts/s of single photons are coupled into a single mode. The system was cooled to cryogenic temperatures and can be coupled evanescently to other nanophotonic structures, such as microresonators. It is suitable for integrated quantum transmission experiments, two-photon interference, quantum-random-number generation. As a nanoprobe it can be used for well localized, ultra-sensitive sensing applications such as nanomagnetometry.

* Schroeder et al. Nano Letters 11, 198, 2011

SYPC 1.5 Thu 12:00 V47.01

Towards optical quantum logic: Source, interface and memory — Jerome Dilley, Peter B. R. Nisbet-Jones, •Annemarie Holleczek, Oliver Barter, and Axel Kuhn — Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU

We present a highly efficient, deterministic source of indistinguishable photons which is based on a vacuum stimulated Raman process (V-STIRAP) in a strongly coupled atom-cavity system [1]. This device operates intermittently for periods of up to $100\mu s$, with a single-photon repetition rate of 1 MHz, and an efficiency of greater than 65% [2]. The single photons are not only produced on demand but also with total control of their shape and intrinsic phase. In addition, we present a scheme how a single photon can be reabsorbed by the emitting atom as this is the key to a single-photon quantum memory [3].

[1] A. Kuhn and D. Ljunggren, Contem. Phys. **51**, 298 (2010).
[2] P. B. R. Nisbet-Jones, et al., New J. Phys. **13**, 103036 (2011).
[3] J. Dilley, et al., arXiv 1105.1699 (2011).

SYPC 1.6 Thu 12:15 V47.01

Asymmetric-coupled vertical quantum dots: Towards a light controlled quantum gate — •Elisabeth Koroknay[1], Christian Kessler[1], Matthias Reischle[1], Ulrich Rengstl[1], Moritz Bommer[1], Robert Rossbach[1], Heinz Schweizer[2], Michael Jetter[1], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Allmandring 3, 70569 Stuttgart, Germany — [2]4. Physikalisches Institut, Pfaffenwaldring 57, 70569, Stuttgart, Germany

In this talk we show the route towards the realization of a laterally and vertically positioned triple dot structure consisting of a tunnel-coupled vertical asymmetric double quantum dot structure (ADQD) and a single dot (larger than the ADQD). The triple dot structure serves as a quantum gate with the ADQD as source dot and the large dot as target dot. The coupling between source and target is achieved by light induced dipole fields originating from the ADQD which influence via the Stark effect the target dot transition.

The quantum dot (QD) structures are grown by metal-organic vapor-phase epitaxy (MOVPE) on GaAs substrates. The ADQD consists of two vertically stacked differently sized InP QDs embedded in GaInP, grown lattice matched to GaAs. Time integrated and time-resolved photoluminescence (PL) measurements have been performed on ADQDs to investigate the coupling behavior. For the target QD the InGaAs material system was chosen to clearly differ in emission energy of the InP ADQD. Next to our growth efforts we present structural and optical analysis of the current status.

SYPC 2: From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication 2

Time: Thursday 14:00–16:00 Location: V47.01

Invited Talk SYPC 2.1 Thu 14:00 V47.01

Coherent population trapping in quantum dot molecules — Katharina Weiss, Jeroen Elzerman, and •Atac Imamoglu — ETH, Zurich, Switzerland

Low-frequency atomic transitions that are insensitive to magnetic fields play a fundamental role in precision measurements and metrology. In contrast, most solid-state quantum systems are subject to either strong electric or magnetic field fluctuations that severely limit their T2*coherence time. In this talk, we will describe experiments where we demonstrate that by adjusting the applied bias voltage and the magnetic field, spin singlet and triplet ground states of an optically active quantum dot molecule can be rendered insensitive to both electric and magnetic field fluctuations. By using coherent population trapping on transitions to a common optically excited state, we show that the singlet-triplet T2* time can exceed 100 nanoseconds. The rich optical spectrum of this quantum system exhibiting recycling transitions for spin measurements and indirect excitons for spin-state dependent long-range dipole-dipole interactions, potentially allow for applications in quantum information processing.

Invited Talk SYPC 2.2 Thu 14:30 V47.01

Nanophotonic Interconnection Networks for Performance-Energy Optimized Computing — •Keren Bergman — Department of Electrical Engineering, Columbia University, New York, NY

As chip multiprocessors (CMPs) scale to increasing numbers of cores and greater on-chip computational power, the gap between the available off-chip bandwidth and that which is required to appropriately feed the processors continues to widen under current memory access architectures. For many high-performance computing applications, the bandwidth available for both on- and off-chip communications can play a vital role in efficient execution due to the use of data-parallel or data-centric algorithms. Electronic interconnected systems are increasingly bound by their communications infrastructure and the associated power dissipation of high-bandwidth data movement. Recent advances in chip-scale silicon photonic technologies have created the potential for developing optical interconnection networks that can offer highly energy efficient communications and significantly improve computing performance-per-Watt. This talk will examine the design and performance of photonic networks-on-chip architectures that support both on-chip communication and off-chip memory access in an energy efficient manner.

SYPC 2.3 Thu 15:00 V47.01

Controlled coupling of single solid-state quantum emitters to optical antennas — •Markus Pfeiffer[1,2], Klas Lindfors[1,2], Paola Atkinson[3], Armando Rastelli[3], Oliver Schmidt[3], Harald Giessen[2], and Markus Lippitz[1,2] — [1]Max Planck Institute for Solid State Research, Stuttgart, Germany — [2]University of Stuttgart, Stuttgart, Germany — [3]IFW Dresden, Dresden, Germany

Plasmonic structures combined with stable solid-state quantum emitters are a promising approach to integrated photonic circuits and quantum optics applications. One of the main challenges in realizing such structures is the controlled positioning of single plasmonic structures next to a single emitter. To address this challenge, we have developed an electron-beam lithography based technique that enables fabrication of nanostructures aligned with respect to single self-assembled semiconductor quantum dots with nanometer precision.

We have applied our fabrication method to couple excitons in single quantum dots with plasmons in rod-shaped optical antennas. The plasmon-exciton coupling is manifested as a significant change in the polarization state of the photoluminescence. We investigate the strength of the coupling as a function of the position of the quantum dot with respect to the antenna. We observe large variations in the polarization properties of the luminescence as the quantum dot is placed at different positions in the vicinity of an antenna.

SYPC 2.4 Thu 15:15 V47.01

Telecom wavelength semiconductor-superconductor based quantum emitters — •Claus Hermannstädter[1,2], Hirotaka Sasakura[1], Nahid A. Jahan[1], Jae-Hoon Huh[1], and Ikuo Suemune[1] — [1]Hokkaido University, Sapporo, Japan — [2]JSPS

Practical integrated single and entangled photon-pair sources in the telecommunication band are attracting plenteous attention for on-chip and fiber-based technologies. We use semiconductor quantum dot (QD) and light emitting diode (LED) structures grown on InP substrates as quantum emitters in the spectral range between 1.3 and 1.6 μm.

We present one approach to realize a source of single photons and polarization entangled photon-pairs by isolating a small number of QDs inside InGaAlAs nano-mesas of around 150 nm diameter. For enhanced photon extraction, the nano-mesas are embedded in metal and the InP substrate is removed [Jpn. J. Appl. Phys. 50, 06GG02 (2011); New. J. Phys., submitted (2011)]. Another approach for the realization of entangled photon-pairs is the concept of Cooper-pair (Josephson) LEDs [PRL 103, 187001 (2009); PRL 107, 157403 (2011)]. InGaAs LEDs are processed with superconducting Niobium electrodes for the injection of electron Cooper-pairs. The presence of these Cooper-pairs at the p-n-junction leads to their radiative recombination with two normal holes and thus the simultaneous generation of entangled photon-pairs. Both demonstrated approaches have the potential to be combined to "Cooper-pair QD-LEDs" and allow for integration on semiconductor chips as parts of larger devices. Moreover, the target wavelength of 1.55 μm for application in silica fiber networks is successfully covered.

SYPC 2.5 Thu 15:30 V47.01

Si-based light emitters in integrated photonic circuits for smart biosensor applications — •Susette Germer — Institute of Ion-Beam Physics and Materials Research (FWI), Helmholtz-Centre Dresden-Rossendorf (HZDR), Dresden, Germany

In this report we present our recent developments for utilizing the Si-based light emitter consisting of a MOS structure for the detection of organic pollutants. In the latest approach the light emitters are intended to serve as light sources in smart biosensors. Now we discuss our concept of an integrated light emitter and a receiver in a dielectric waveguide structure below the bioactive layer for the detection of harmful substances, like synthetic estrogens or plasticizer in drinking water. Optical properties of waveguides, e.g. the transmission, are very sensitive to changes of the effective refraction index, which might be induced by the immobilization of biomolecules on the waveguide surface or in cavity structures, e.g. photonic crystals. The guiding of the light depends on the geometry and material composition of the waveguide. First waveguides were fabricated through plasma enhanced chemical vapor deposition (PECVD) and optical photolithography with following etching steps. Afterwards the layer thicknesses were analyzed by ellipsometry and the surface roughness via scanning electron microscopy (SEM). However, the investigation of the different waveguides will be allowed through finite element method (FEM) simulations (COMSOL) and experimentally through a setup for the optical transmission measurement. In summary, this lab-on-a-chip system provides fast light transmission and achieves further portability and miniaturization.

SYPC 2.6 Thu 15:45 V47.01

Arrayed waveguide grating based interrogator for fiber Bragg grating sensors: measurement and simulation — •Jan Koch[1,2], Martin Angelmahr[1], and Wolfgang Schade[1,2] — [1]Fraunhofer Heinrich Hertz Institute, Am Stollen 19B, 38640 Goslar, Germany — [2]Clausthal University of Technology, Am Stollen 19B, 38640 Goslar, Germany

Fiber Bragg grating (FBG) strain sensors offer great potential. Compared to strain gauges they are small and lightweight, can easily be multiplexed, and are immune to electromagnetic disturbance. In addition the new femtosecond laser processed FBG sensors are very robust and easy to handle. However, the main disadvantage of those fiber-optical measurement systems lies within the applied FBG interrogator, which usually consists of expensive and fragile components.

In this work a FBG interrogator based on an arrayed waveguide grating (AWG) chip, known as cost efficient and very stable multi-/demultiplexer module in the telecommunication industry, is presented. In order to achieve high wavelength resolution, the interpretation of the response signal of the FBG strain sensors has to be done very carefully. Hence, the required evaluation algorithm is examined in detail. The corresponding calibration parameters are determined by calibration measurements and by simulations. The system simulation provides additional information for the error estimation of the measurand.

SYPC 3: From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication 3

Time: Friday 10:30–12:30 Location: V47.02

SYPC 3.1 Fri 10:30 V47.02

Towards quantum dot - photon entanglement swapping — •Tim Kroh, Otto Dietz, Andreas W Schell, and Oliver Benson — AG Nano Optics, Institut für Physik, HU Berlin

The distance of fiber based quantum communication can be increased arbitrarily with the help of quantum repeaters. In realizations of quantum repeater architectures involving semiconductor quantum dots (QDs) entanglement swapping between two dissimilar entangled states, i.e. an entangled QD-photon state on one hand and a photon pair on the other hand is a crucial operation. A first experiment involving a quantum dot and a photon pair was demonstrated recently [1].

The next important step is to demonstrate two-photon interference between a single photon from a quantum dot and a photon from an entangled photon pair. To achieve indistinguishability at least one of the photon sources has to be tunable. We present first experiments in this direction where we investigate different semiconductor QDs which are tunable with respect to photon pair sources.

[1] Solomon et al., Phys. Rev. Lett. 107, 157402

SYPC 3.2 Fri 10:45 V47.02

Heralded Quantum Entanglement between two Crystals — •Christoph Clausen, Imam Usmani, Félix Bussières, Nicolas Sangouard, Mikael Afzelius, and Nicolas Gisin — GAP-Optique, Université de Genève, Switzerland

A crucial requirement for quantum networks is the ability to entangle quantum nodes. With the help of a quantum repeater, for example, quantum information can be transmitted at a rate that scales polynomially with distance, whereas the exponential loss in direct transmission of single photons through optical fibers inhibits quantum communication over distances larger than a few hundred kilometers. This is only possible if two remote quantum memories can be entangled in a heralded fashion.

We present the creation of heralded entanglement between two ensembles of rare-earth ions doped into separate crystals. A heralded single photon is sent through a 50/50 beamsplitter with one crystal at each output acting as quantum memories. The absorption of the photon by one of the crystals leads to a single collective excitation delocalized between the two crystals. The entanglement between the crystals is revealed by mapping it back to optical modes and performing a series of measurements that provide a lower bound on the concurrence of the retrieved light state. Our results are a step on the way towards quantum networks based on solid-state resources.

SYPC 3.3 Fri 11:00 V47.02

An All-Integrated PDC Source for Heralded Single Photons in Ti:$LiNbO_3$ Waveguides — •Stephan Krapick, Benjamin Brecht, Viktor Quiring, Harald Herrmann, Wolfgang Sohler, and Christine Silberhorn — IQO, Uni Paderborn

Many applications in quantum information networking rely on heralded single photons. We present a waveguide-based source for the efficient generation of heralded single photons in Ti-diffused Lithium Niobate. Pumping with pulsed light at 532 nm, photon pairs at around 810nm and 1550nm are created in a type-I PDC process and split up into signal and idler beams using an integrated WDM coupler on the very same chip. We will optimize our source and aim to achieve heralded efficiencies of up to 93% in coincidence measurements, which are theoretically limited by the waveguide-fiber-coupling.

SYPC 3.4 Fri 11:15 V47.02

The inhomogeneous broadening of the zero phonon line of single nitrogen-vacancy centers in nano-diamonds — •Nikola Sadzak, Janik Wolters, and Oliver Benson — Humboldt Universität zu Berlin, Nano-optics, Newtonstraße 15, D-12489 Berlin, Germany

Color centers in diamond have proven to be a promising resource for quantum technology applications. In particular, the negatively charged nitrogen-vacancy defect (NV) center in bulk diamond is attractive as a source of indistinguishable single photons, as it provides a narrow zero phonon line (ZPL) at the optical $^3A \rightarrow ^3E$ transition at 638 nm. However, for integrated solid state devices, nano-diamonds with single NV centers are preferable as they can be manipulated and integrated in different photonic structures [1, 2]. Here, a major problem is the inhomogeneous broadening of the ZPL due to spectral diffusion. Performing interferometric and photon-correlation measurements we determine the time-scale of the spectral diffusion and gain further knowledge about the underlying processes.

[1] J. Wolters et al., *Enhancement of the zero phonon line emission from a single nitrogen vacancy center in a nanodiamond via coupling to a photonic crystal cavity*, Appl. Phys. Lett. **97**, 141108 (2010)

[2] A. Schell et al., *A scanning probe-based pick-and-place procedure for assembly of integrated quantum optical hybrid devices*, Rev. Sci. Instrum. **82**, 073709 (2011)

SYPC 3.5 Fri 11:30 V47.02

Ultrafast all-optical switching by single photons — •Thomas Volz, Andreas Reinhard, and Atac Imamoglu — Institute of Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland

While two-color spectroscopy of the Jaynes-Cummings ladder has been performed in the microwave domain, it has so far not been demonstrated for cavity QED experiments in the optical domain. Here, we report on frequency- and time-resolved two-color spectroscopy of a strongly coupled quantum dot-cavity system which consists of a single self-assembled InGaAs quantum dot positioned at the field maximum of a photonic crystal L3 cavity. The coupled system is highly non-linear as witnessed by strong photon blockade on both fundamental polariton transitions [1]. Two (near-)resonant laser pulses with variable relative time delay are used to probe the non-linear system dynamics. With the center frequency of the first laser pulse fixed to one of the fundamental polariton transitions, we record the non-linear system response as a function of the center frequency of the second laser pulse. We obtain a clear signature due to the corresponding transition from the first to the second Jaynes-Cummings manifold. By varying the time delay between the laser pulses, we demonstrate all-optical switching by single photons on picosecond timescales [2]. Besides the single-photon switching, the present device can also be used as a single-photon pulse correlator.

[1] A. Reinhard et al., accepted for publication in Nature Photonics, arXiv:1108.3053.

[2] T. Volz et al., submitted for publication, arXiv:1111.2915.

SYPC 3.6 Fri 11:45 V47.02

Influence of the excitation pulse width on the purity of single-photon emission from light emitting diodes — •Fabian Hargart[1], Christian Kessler[1], Matthias Reischle[1], Wolfgang-Michael Schulz[1], Marcus Eichfelder[1], Robert Rossbach[1], Michael Jetter[1], Paul Gartner[2], Matthias Florian[2], Christopher Gies[2], Frank Jahnke[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart — [2]Institut für Theoretische Physik, Universität Bremen, Postfach 330 440, 28334 Bremen

For many applications in quantum information single-photons on demand are desirable. Electrically driven semiconductor quantum dots (QDs) are a promising solution due to their tailorable emission energy and the integration in well-known semiconductor devices.

Pulsed lasers afford an almost instantaneous excitation of the QDs compared to their decay time. In contrast, electrical pulse generators feature pulsewidths only down to several 10 ps. Therefore we determine the influence of the excitation pulses on the purity of single-photon emission from InP/GaInP quantum dots. For rising widths we observe an increasing $g^{(2)}(0)$ - value, which we relate to an increasing probability of further excitations during one single cycle. Using autocorrelation measurements with high temporal resolution we can distinguish the background contribution from re-excitation processes on the non-vanishing $g^{(2)}(0)$-value. Theoretical investigations are in a good agreement with the experimental results.

SYPC 3.7 Fri 12:00 V47.02

Quantum Simulations with a two-dimensional Quantum Walk — •Andreas Schreiber[1,2], Aurél Gábris[3], Peter P. Rohde[1,4], Kaisa Laiho[1], Martin Štefaňák[3], Václav Potoček[3], Craig Hamilton[3], Igor Jex[3], and Christine Silberhorn[1,2] — [1]IQO Group, MPI for the Science of Light,91058 Erlangen, Germany. — [2]Integrated Quantum Optics, Applied Physics, University of Paderborn, 33098 Paderborn, Germany — [3]Department of Physics, FNSPE, Czech Technical University in Prague, Praha, Czech Republic. — [4]Centre for Engineered Quantum Systems, Department of Physics and Astronomy, Macquarie University, Sydney NSW 2113, Australia

The concept of quantum walks has become a promising candidate for quantum computation and simulations of quantum transfer. Although theoretical models already exploit the power of higher-dimensional quantum walks all experimental implementations so far were limited to a spread in a single dimension.

Here we present the first implementation of a quantum walk in a scalable and flexible two-dimensional system. We demonstrate a highly coherent evolution of photons in an optical fiber network, allowing for a spread over up to 169 positions after 12 steps. Having full control over the quantum coin enables us to simulate entanglement in bipartite systems with conditioned interactions including non-linearities or two-particle scattering.

SYPC 3.8 Fri 12:15 V47.02

Quantum key distribution using a single-photon emitting diode in the red spectral range — •Christian Kessler[1], Fabian Hargart[1], Markus Rau[2], Martin Fuerst[2], Wolfgang-Michael Schulz[1], Marcus Eichfelder[1], Robert Rossbach[1], Sebastian Nauerth[2], Michael Jetter[1], Harald Weinfurter[2,3], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, 70569 Stuttgart — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 München — [3]Max-Planck-Institut für Quantenoptik, 85748 Garching

In 1984 Bennett and Brassard presented a scheme for secure quantum key distribution (QKD), the so-called BB84 protocol. Several QKD-experiments have been arranged with strongly attenuated lasers. But due to multi-photon emission additional shrinking of the key compared to systems using single-photon sources (SPS) is necessary. Therefore, using a SPS afford higher key rates at the same total count rate.

In this report we present free-space quantum key distribution experiments using an electrically driven SPS, based on InP quantum dots. A polarizer in combination with an electro-optical modulator prepare the polarization state. After a free-space channel of about 50 cm the beam is detected and analyzed by a single-photon polarization analyzer setup. The influence of several excitation parameters, e.g. the peak-to-peak voltage, the DC voltage and the pulse width on the $g^{(2)}(0)$-value and the transfer rate are investigated. Sifted key rates up to 81.6 kBits/s at a quantum bit error-rate of 4.2 % and a $g^{(2)}(0)$-value of 0.48 were achieved.