# Q 28: Quantum Information: Quantum Communication 1

Time: Wednesday 10:30–12:45 Location: SCH A01

Q 28.1 Wed 10:30 SCH A01

**Faked-state attacks on commercial quantum key distribution** — •Nitin Jain[1,2], Lars Lydersen[3,4], Christoffer Wittmann[1,2], Carlos Wiechers[5], Dominique Elser[1,2], Christoph Marquardt[1,2], Vadim Makarov[3,4], Johannes Skaar[3,4], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Guenther-Scharowsky-Str. 1, Bau 24, 91058, Erlangen, Germany — [2]Institut fuer Optik, Information und Photonik, University of Erlangen-Nuremberg, Staudtstraße 7/B2, 91058, Erlangen, Germany — [3]Department of Electronics and Telecommunications, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway — [4]University Graduate Center, NO-2027 Kjeller, Norway — [5]Departamento de Fisica, Campus Leon, Universidad de Guanajuato, Lomas del Bosque 103, Fracc. Lomas del Campestre, 37150, Leon, Gto, Mexico

We experimentally review an off-the-shelf commercial quantum key distribution system (QKD) from ID Quantique to identify loopholes and exploit vulnerabilities by simulating and performing attacks on it. In particular, we devise faked-state attacks against the avalanche photo diode (APD) based detectors of this QKD system. We have shown several successful proof-of-principle attacks through experiments and simulations.

Q 28.2 Wed 10:45 SCH A01

**Highly Efficient Frequency Conversion at the Single Photon Level** — Sebastian Zaske, •Andreas Lenhard, and Christoph Becher — Universität des Saarlandes, FR 7.2 Experimentalphysik, Campus E2.6, 66123 Saarbrücken

Much recent progress has been achieved in the fabrication of single photon emitters based on color centers in diamond, e.g., SiV-centers emitting at 738 nm [1]. However, efficient single photon transmission in future quantum networks requires wavelengths in the low loss band of optical fibers around 1550 nm. In order to bridge this wavelength gap we aim at frequency downconversion of single photons emitted from a SiV-center. As a first step we investigate difference frequency mixing of attenuated laser pulses at 738 nm with a strong continuous light field at 1404 nm in a ZnO-doped periodically poled $LiNbO_3$ ridge waveguide and yield converted photons at 1557 nm. An internal conversion efficiency exceeding 80% is achieved. Together with a high coupling efficiency of 93% into the waveguide at 738 nm this leads to an overall conversion efficiency of about 30% for our setup. We further investigate the noise properties of the mixing process by measuring the spectrum between 1450-1600 nm. The dominating noise source in our experiment is identified to be spontaneous (Stokes) Raman scattering induced by the strong pump field at 1404 nm.

[1] E. Neu, D. Steinmetz, J. Riedrich-Möller, S. Gsell, M. Fischer, M. Schreck, and C. Becher, "Single photon emission from silicon-vacancy centres in CVD-nano-diamonds on iridium," accepted for publication in New. J. Phys. (2010).

Q 28.3 Wed 11:00 SCH A01

**Daylight Free Space Quantum Communication using Continuous Polarization Variables** — •Christian Peuntinger[1,2], Bettina Heim[1,2], Christoffer Wittmann[1,2], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max-Planck-Institut für die Physik des Lichts, Günther-Scharowsky-Str. 1 / Bau 24, 91058 Erlangen, Deutschland — [2]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Staudtstrasse 7 / B2, 91058 Erlangen, Deutschland

We present our experimental work on quantum communication using a free space quantum channel of 1.6km in an urban environment. In our prepare-and-measure setup, we perform binary encoding of continuous polarization states. The signal states are measured using homodyne detection with the help of a local oscillator (LO). Both, signal and LO, are sent through the free-space channel while occupying the same spatial mode. This leads to excellent interference at the detection and an auto-compensation of the phase fluctuations introduced by the channel. Additionally the LO automatically acts as a spatial and spectral filter of the signal, which allows for unrestrained daylight operation. We have compared Stokes measurements on the quantum states before and after passing the free space channel using different modulation patterns. This allows for investigation of the influences of the turbulent atmosphere on our quantum states. A main drawback when working with an atmospheric channel is spatial beam jitter. We studied these kind of effects in detail and will present methods to reduce their impact.

Q 28.4 Wed 11:15 SCH A01

**Broadband mode selector based on spectrally engineered sum frequency generation** — •Benjamin Brecht[1], Andreas Eckstein[1,2], and Christine Silberhorn[1,2] — [1]Integrated Quantum Optics, Applied Physics, University of Paderborn, 33098 Paderborn — [2]Max Planck Institute for the Science of Light, 91058 Erlangen

We propose broadband mode selection, a method for accessing the spectrally broadband mode structure of ultrafast quantum states of light. This opens up a new degree of freedom for quantum information coding which was unitl now not practically accessible. Based on spectrally engineered sum frequency generation (SFG), it allows us to pick well-defined pulsed broadband modes from an ultrafast multi-mode state without destroying its coherent pulse characteristics. By shaping the pulse of the bright SFG pump beam, different orthogonal broadband modes matched to the intrinsic structure of the input state can be addressed individually, extracted spatially with near unit efficiency and interconverted into each other for later interference.

Q 28.5 Wed 11:30 SCH A01

**The excitation of a two-level atom by a propagating light pulse** — •Yimin Wang, Lana Sheridan, and Valerio Scarani — Centre for Quantum Technologies, Singapore

State mapping between atoms and photons, and photon-photon interactions play an important role in scalable quantum information processing. We consider the interaction of a two-level atom with a quantized *propagating* pulse in free space and study the probability $P_e(t)$ of finding the atom in the excited state at any time $t$. This probability is expected to depend on (i) the quantum state of the pulse field and (ii) the overlap between the pulse and the dipole pattern of the atomic spontaneous emission. In the full three-dimensional vector model for the field, we show that the second effect is captured by a single parameter $\Lambda \in [0, 8\pi/3]$, obtained by weighing the numerical aperture with the dipole pattern. Then $P_e(t)$ can be obtained by solving time-dependent Heisenberg-Langevin equations. We provide detailed solutions for both single-photon states and coherent states and for various shapes of the pulse. By optimizing the pulse bandwidth of each kind of pulse with specific shapes, the maximum excitation probability is shown respectively. The effect of mean photon numbers for coherent state pulse is also analyzed.

**Reference**
[1] G. Zumofen *et al.*, Phys. Rev. Lett. **101**, 180404 (2008).
[2] M. Stobińska *et al.*, Euro. Phys. Lett., **86**, 14007 (2009).
[3] M. K. Tey *et al.*, Nature Physics **4**, 924 (2008).
[4] Y. M. Wang *et al.*, arXiv: 1010.4661v1, (2010).

Q 28.6 Wed 11:45 SCH A01

**Lenses as an Atom-Photon Interface: A Simple Model** — •Colin Teo[1] and Valerio Scarani[1,2] — [1]Centre for Quantum Technologies, Singapore — [2]Department of Physics, National University of Singapore, Singapore

Strong interaction between the light field and an atom is often achieved with cavities. Recent experiments have used a different configuration: a propagating light field is strongly focused using a system of lenses, the atom being supposed to sit at the focal position. In reality, this last condition holds only up to some approximation; in particular, at any finite temperature, the atom position fluctuates. We present a formalism that describes the focalized field and the atom sitting at an arbitrary position. As a first application, we show that thermal fluctuations do account for the extinction data reported in [1].

**References:**
[1] M. K. Tey *et al.*, Nature Physics **4**, 924 (2008)
[2] M. K. Tey *et al.*, New Jour. Phys. **11**, 043011 (2009)

Q 28.7 Wed 12:00 SCH A01

**Rate analysis for a hybrid quantum repeater** — •Nadja Kolb Bernardes[1,2], Ludmila Praxmeyer[3], and Peter van Loock[1,2] — [1]OQI Group, MPL, Erlangen, Germany — [2]Institute of Theoretical Physics I, University Erlangen-Nuremberg, Erlangen, Germany — [3]Institute of Physics, Nicoulaus Copernicus University, Torun, Poland

We present a detailed rate analysis for a hybrid quantum repeater [1, 2] assuming perfect memories and using optimal probabilistic entanglement generation and deterministic swapping routines [3]. The hybrid quantum repeater protocol is based on atomic qubit-entanglement distribution through optical coherent-state communication. An exact, analytical formula for the rates of entanglement generation in quantum repeaters is derived, including a study on the impacts of entanglement purification and multiplexing strategies. More specifically, we consider scenarios with as little purification as possible and we show that for sufficiently low local losses, such purifications are still more powerful than multiplexing. In a possible experimental scenario, our hybrid system can create near-maximally entangled (F=0.98) pairs over a distance of 1280 km at rates of the order of 100 Hz.

[1] P. van Loock *et al.*, Phys. Rev. Lett. **96**, 240501 (2006).

[2] P. van Loock *et al.*, Phys. Rev. A **78**, 062319 (2008).

[3] N. K. Bernardes, L. Praxmeyer and P. van Loock, arXiv:1010.0106v1 (2010).

Q 28.8 Wed 12:15 SCH A01

**Secret key rates in quantum key distribution using optimization of Rényi entropies** — •Silvestre Abruzzo, Markus Mertz, Hermann Kampermann, and Dagmar Bruss — Heinrich-Heine-Universität Düsseldorf, Institut für Theoretische Physik III, Düsseldorf, Germany

The analysis of a quantum key distribution(QKD) protocol considering finite resources is a new research field. In this talk we will present a new bound for the secret key rate based on the optimization of Rényi entropies, and we will show how to estimate it for finite number of signals. We will explicitly calculate this bound for the symmetric six-state protocol and show that in comparison with other relevant approaches it leads to higher key rates.

Q 28.9 Wed 12:30 SCH A01

**Experimental optimum unambiguous discrimination of two mixed single-photon states** — •Gesine Steudle[1], Sebastian Knauer[1], Ulrike Herzog[1], Erik Stock[2], Dieter Bimberg[2], and Oliver Benson[1] — [1]Humbolt-Universität Berlin, AG Nanooptik, Newtonstr. 15, 12489 Berlin — [2]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin

The discrimination of quantum states [1,2 ] is a fundamental challenge in quantum communication. Particularly, the discrimination of two non-orthogonal quantum states can be performed unambiguously only at the expense of admitting inconclusive results.

In this contribution we present an experimental setup for optimum unambiguous discrimination between two non-orthogonal mixed states [3,4]. We show experimental results for two mixed single-photon states. The single photon source is based on Stranski-Krastanow-grown InAs dots which are embedded in a pin-junction to establish electrical pumping [5].

[1] J. A. Bergou et al., Lect. Notes Phys. 649, 417-465 (Springer, Berlin, 2004)

[2] S. M. Barnett and S. Croke, Adv. Opt. Photon. 1, 238-278 (2009)

[3] U. Herzog, Phys. Rev. A 75, 052309 (2007)

[4] U. Herzog and O. Benson, J. Mod. Opt. 56, 1362 (2009)

[5] A. Lochmann et al., Electron. Lett. 42, 774 (2006)