Q 62: Quantum Information: Quantum Computing and Communication III

Time: Friday 11:00–12:45 Location: e214

Q 62.1 Fri 11:00 e214

Ultrafast Fault-Tolerant Long-Distance Quantum Communication with Static Linear Optics — •Fabian Ewert and Peter van Loock — Institut für Physik, Johannes Gutenberg-Universität, Staudingerweg 7, D-55128 Mainz

We present an all-optical, ultrafast scheme for long-distance quantum communication that can handle both photon losses and various depolarizing errors, e.g., caused by faulty detectors and resource states. The scheme is based on quantum parity encoded qubits and static linear optics. Nonlinear effects are only required for the generation of encoded qubits and Bell states where we propose to use coherent photon conversion which also allows for a static setup and, in principle, an on-chip integration.

Q 62.2 Fri 11:15 e214

Upgrading existing Laser Communication Terminals for Satellite Quantum Communication — •Dominique Elser[1], Kevin Günthner[1], Imran Khan[1], Birgit Stiller[1], Christoph Marquardt[1], Gerd Leuchs[1], Karen Saucke[2], Daniel Tröndle[2], Frank Heine[2], Stefan Seel[2], Peter Greulich[2], Herwig Zech[2], Björn Gütlich[3], Ines Richter[3], and Rolf Meyer[3] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany and Institute of Optics, Information and Photonics, Friedrich-Alexander University Erlangen-Nürnberg (FAU), Erlangen, Germany — [2]Tesat-Spacecom GmbH & Co. KG, Backnang, Germany — [3]Space Administration, German Aerospace Center (DLR), Bonn, Germany

By harnessing quantum effects, we nowadays can use encryption that is information-theoretically secure. These fascinating quantum features have been implemented in metropolitan quantum networks around the world. In order to interconnect such metropolitan networks over long distances, optical satellite communication is the method of choice. Standard telecommunication components allow one to efficiently implement quantum communication by measuring field quadratures (continuous variables). This opens the possibility to upgrade the existing Laser Communication Terminals (LCTs) to quantum key distribution (QKD). First satellite measurement campaigns are currently validating our approach [1].

[1] D. Elser *et al.*, International Conference on Space Optical Systems and Applications (IEEE ICSOS 2015), October 27 and 28, 2015, New Orleans, USA, arXiv:1510.04507 [quant-ph] (2015).

Q 62.3 Fri 11:30 e214

Atmospheric Quantum Key Distribution with Squeezed States — •Kevin Günthner[1], Christian Peuntinger[1], Christian S. Jacobsen[2], Dominique Elser[1], Vladyslav C. Usenko[3], Radim Filip[3], Ulrik L. Andersen[2], Christoph Marquardt[1], and Gerd Leuchs[1] — [1]Max Planck Institute for the Science of Light (MPL), Erlangen, Germany and Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) — [2]Department of Physics, Technical University of Denmark, Kongens Lyngby, Denmark — [3]Department of Optics, Palacký University, Olomouc, Czech Republic

In Continuous Variable Quantum Key Distribution, Gaussian quantum states and homodyne detection are used to distribute a secret key between two parties.

Recently it was shown that — in comparison to coherent states — squeezed states can provide higher key rates in presence of channel noise and realistic reconciliation efficiency [1].

This protocol was already successfully implemented in laboratory conditions [2]. Now we verify the feasibility of this approach with an urban free-space channel. We eliminate atmospheric phase noise by using polarization squeezed states benefiting from a decoherence free subspace [3].

[1] V. C. Usenko and R. Filip, New J. Phys. **13**, 113007 (2011).
[2] C. S. Jacobsen *et al.*, arXiv:1408.4566 (2014).
[3] C. Peuntinger *et al.*, Phys. Rev. Lett. **113**, 060502 (2014).

Q 62.4 Fri 11:45 e214

Towards practical device-independent quantum key distribution with spontaneous parametric downconversion sources, on-off photodetectors and entanglement swapping — •Kaushik Seshadreesan[1,2], Masahiro Takeoka[2], and Masahide Sasaki[2] — [1]Max Planck Institute for the Science of Light, Guenther-Scharowsky-Str. 1/Bldg. 24, D-91058 Erlangen, Germany — [2]National Institute of Information and Communications Technology, Koganei, Tokyo 184-8795, Japan

Device-independent quantum key distribution (DIQKD) guarantees unconditional security of secret key without making assumptions about the internal workings of the devices used. The security of DIQKD relies on the verification of nonlocal correlations via the violation of a Bell's inequality in a loophole-free test. The primary challenge in realizing DIQKD in practice is the detection loophole problem associated with optical tests of Bell's inequalities over long distances. We revisit a proposal [1] to use a linear optics-based entanglement swapping relay to counter this problem by considering realistic models for the entanglement sources and photodetectors. More precisely, we consider (a) polarization-entangled states based on a pair of pulsed SPDCs that have infinitely higher order multiphoton components and multimode spectral structure, and (b) on-off photodetectors that have non-unit efficiencies and non-zero dark count probabilities. Our results show that the imperfect entanglement swapping relay-based scheme can still enable positive secret key rates at distances of about a 100 kilometers.

[1] Curty and Moroder, Phys. Rev. A 84, 010304(R) (2011).

Q 62.5 Fri 12:00 e214

Continuous-variable high-speed quantum key distribution compatible with telecom networks — •Imran Khan[1,2], Birgit Stiller[1,2,3], Kevin Jaksch[1,2], Christian Peuntinger[1,2], Kevin Günthner[1,2], Jonas Geyer-Ramsteck[1,2], Nitin Jain[1,2,4], Dominique Elser[1,2], Christoph Marquardt[1,2], and Gerd Leuchs[1,2,5] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuernberg, 91058 Erlangen, Germany — [3]Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), School of Physics, University of Sydney, NSW 2006, Australia — [4]Center for Photonic Communication and Computing, EECS Department, Northwestern University, Evanston, Illinois 60208, USA — [5]Department of Physics, University of Ottawa, 25 Templeton, Ottawa, ON, Canada

The ability to securely distribute keys at high rates is of crucial importance for the future of practical quantum key distribution (QKD). In this work, we show our progress on implementing a GHz rate continuous-variable QKD setup in a realistic telecom environment, employing wavelength-division multiplexing. We discuss how these high transmission rates increase the robustness against finite-size effects and realistic noise sources (e. g. in the low frequency regime; also relevant for free-space channels with fluctuating transmission). We also show the experimental status on implementing a local oscillator, which is situated at the receiver.

Q 62.6 Fri 12:15 e214

Large-Alphabet Time-Frequency Quantum Key Distribution — •Jasper Rödiger[1,2], Nicolas Perlot[1], Matthias Leifgen[2], Robert Elschner[1], Roberto Mottola[2], Oliver Benson[2], and Ronald Freund[1] — [1]Fraunhofer Heinrich-Hertz Institut, Berlin, Germany — [2]Nanooptik AG, Humboldt-Universität zu Berlin, Berlin, Germany

We investigate a quantum key distribution (QKD) scheme, referred to as time-frequency (TF-) QKD, based on the time-frequency uncertainty relation. It is a BB84-like QKD protocol with the two bases being modulations in time and frequency, namely the pulse position modulation (PPM) and frequency shift keying (FSK). Assuming one photon per pulse, measuring in one of the bases increases the measurement uncertainty in the other and thus destroys most information encoded there, similar to BB84.

TF-QKD is mostly compatible to classical communication technologies. Since PPM is a well-established coding technique in free-space communication and polarization is free for duplexing, TF-QKD is very well suited for free-space communication. In addition it is possible to use a large alphabet, thus to send a high number of bits per photon.

With a proof-of-principle experiment, using two symbols per basis, it was possible to distribute a key with a sifted key rate of 12 kbit/s. More symbols per basis and a higher key-rate are the subjects of current investigation. Numerical simulations identified optimal pulse relations and showed that a larger alphabet increases the secret key rate.

Q 62.7 Fri 12:30 e214

Dissipation enabled efficient excitation transfer from a single photon to a single quantum emitter — •Nils Trautmann and Gernot Alber — Institut für Angewandte Physik, Technische Universität Darmstadt

We propose a scheme for triggering a dissipation dominated highly efficient excitation transfer from a single photon wave packet to a single quantum emitter. This single photon induced optical pumping turns dominant dissipative processes, such as spontaneous photon emission by the emitter or cavity decay, into valuable tools for quantum information processing and quantum communication. It works for an arbitrarily shaped single photon wave packet with sufficiently small bandwidth provided a matching condition is satisfied which balances the dissipative rates involved. Our scheme does not require additional laser pulses or quantum feedback and is not restricted to highly mode selective cavity quantum electrodynamical architectures. In particular, it can be used to enhance significantly the coupling of a single photon to a single quantum emitter implanted in a one dimensional waveguide or even in a free space scenario. We demonstrate the usefulness of our scheme for building a deterministic quantum memory and a deterministic frequency converter between photonic qubits of different wavelengths.