# Q 35: Quantum Information (Quantum Communication) II

Time: Wednesday 14:00–16:00 Location: Q-H12

Q 35.1 Wed 14:00 Q-H12

**Quantum communication networks with solid-state nodes and multi-photon entangled states** — •Durga Dasari[1], Roland Nagy[2], Florian Kaiser[1], and Durga B Dasari[1] — [1]3. Physics Institute, University of Stuttgart, 70569 Stuttgart, Germany — [2]Dept. Elektrotechnik-Elektronik-Informationstechnik, FAU Erlangen-Nürnberg, 91058 Erlangen

Quantum Internet is an entangled communication network in which the quantum nodes are connected by entangled connections established by single photons. Optically active solid-state spin registers have demonstrated their unique potential in quantum computing, communication, and sensing. They can be used to realize scalable quantum networks based on establishing entanglement amongst multiple systems via photonic interference. We will present here schemes to realize memory-enhanced quantum networks based on spin-defects in 4H-SiC [1] and diamond [2].

[1] R. Nagy et al., Appl. Phys. Lett. 118, 144003 (2021). [2] D. Dasari et al., Phys. Rev. B 92, 081301 (2015).

Q 35.2 Wed 14:15 Q-H12

**A portable decoy-state QKD sender** — •Michael Auer[1,2,3], Peter Freiwang[1,2], Adomas Baliuka[1,2], Lukas Knips[1,2,4], and Harald Weinfurter[1,2,4] — [1]Ludwig-Maximilians-Universität, Munich, Germany — [2]Munich Center for Quantum Science and Technology, Munich, Germany — [3]Universität der Bundeswehr München, Neubiberg, Germany — [4]Max-Planck-Institut für Quantenoptik, Garching, Germany

Quantum Key Distribution (QKD) enables secure key exchange, based on fundamental laws of quantum mechanics. Widespread commercial use of this technology requires robust and scalable QKD modules with low cost, size, weight and maintenance.

Here we present a small-size, low-power, FPGA-controlled QKD sender electronics used to drive an array of four vertical-cavity surface-emitting lasers (VCSELs) at 100MHz. The sender is capable of implementing a decoy-state BB84 protocol with four separate driving lanes to create short electrical signals, which allow to individually adjust the pulse-shape and timing for the respective laser diode. With the goal to keep the optics small and mostly passive, the different optical intensities needed for the decoy protocol are created electronically.

Our module enables classical communication and synchronization by modulating a beacon laser, which can be also used for beam tracking. The sender is powered and operated only via a single USB-C host, and features a low power consumption of around 10 watts in total. This, together with its compact size and weight makes it suitable for a broad spectrum of future applications.

Q 35.3 Wed 14:30 Q-H12

**Concepts and development of a receiver for satellite quantum key distribution** — •Conrad Rössler[1,2], Kevin Günthner[1,2], Bastian Hacker[1,2], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany — [2]Friedrich Alexander University Erlangen-Nuremberg, Staudstr. 7/B2, 91058 Erlangen, Germany

Since its first proposal in 1984 with the BB84 protocol, quantum key distribution (QKD) has evolved to a fairly mature and most promising quantum technology. QKD allows two parties to share a key in an information-secure way, which overcomes the potential security threat quantum computers pose to public key cryptography. We present a high-rate fiber integrated quantum receiver for phase-encoded satellite-based QKD as well as the corresponding discrete variable QKD protocol. We highlight concepts for single-photon-detection-based phase locking and real time synchronization of sender and receiver as well as compensation for the Doppler shift and optimized quantum signal processing.

Q 35.4 Wed 14:45 Q-H12

**Open-Source LDPC Error Correction for QKD** — •Adomas Baliuka[1,2], Elsa Dupraz[3], Rengaraj Govindaraj[1,2], Michael Auer[1,2,4], Peter Freiwang[1,2], Lukas Knips[1,2,5], and Harald Weinfurter[1,2,5] — [1]Ludwig-Maximilian-University (LMU), Munich, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Munich, Germany — [3]IMT Atlantique, Lab-STICC, UMR CNRS 6285, F-29238, France — [4]Universität der Bundeswehr München, Neubiberg, Germany — [5]Max Planck Institute of Quantum Optics (MPQ), Garching, Germany

Error correction is an essential step in the classical post-processing of all quantum key distribution (QKD) protocols. We present error correction methods optimized for discrete variable (DV) QKD. Our methods are based on irregular quasi-cyclic (QC) low density parity check (LDPC) codes and state-of-the-art rate adaption techniques, thereby increasing the efficiency for key generation. The codes are freely available as an ongoing open-source project (doi.org/10.5281/zenodo.5589543 and github.com/XQP-Munich/LDPC4QKD).

Q 35.5 Wed 15:00 Q-H12

**Quantum network with interacting network qubits** — •Emanuele Distante, Severin Daiss, Stefan Langenfeld, Stephan Welte, Philip Thomas, Lukas Hartung, Olivier Morin, and Emanuele Distante — Max Planck Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Quantum networks allow the realization of distributed architectures where local network modules, containing addressable memory qubits and linked together via photonic channels, operate as distributed quantum machine. Such architecture represents a promising route to scale up the number of cross-talk free qubits in a quantum computer. Its realization, however, requires strong, controllable interactions among stationary qubits located in different network modules. Here, we report on our progress on the realization of an elementary network link where the interaction among qubits located in separated modules is mediated by traveling photonic qubits. Each module is based on a single $^{87}$Rb atom trapped at the center of an optical cavity. We will show that single photons sequentially reflected off the modules mediate strong interaction between the network qubits allowing the realization of fundamental logic-gate between the remotely located qubits, the faithful transfer of information via a simple/novel teleportation scheme, as well as realization of joint nondestructive measurement on distant qubits.

[1] S. Daiss *et al.*, Science **371**, 614-617 (2021)
[2] S. Langenfeld *et al.*, Phys. Rev. Lett. **126**, 130502 (2021)
[3] S. Welte *et al.*, Nat. Phot. **15**, 504-509 (2021)

Q 35.6 Wed 15:15 Q-H12

**Readout-noise analysis and optimization of a warm vapor EIT memory on the Cs D1 line** — •Luisa Esguerra[1,2], Leon Messner[1,3], Elizabeth Robertson[1,2], Norman Vincenz Ewald[1], Mustafa Gündoğan[1,3], and Janik Wolters[1,2] — [1]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institut für Optische Sensorsysteme, Rutherfordstr. 2, 12489 Berlin, Germany. — [2]TU Berlin, Institut für Optik und Atomare Physik, Hardenbergstr. 36, 10623 Berlin, Germany. — [3]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, Berlin 12489, Germany.

Noise-free quantum memories are a missing building block in the implementation of quantum repeaters, which will be crucial for long distance quantum communication [1]. We have realized a technologically simple, in principle satellite-suited quantum memory in Cesium vapour, based on electromagnetically induced transparency (EIT) on the ground states of the Cs D1 line, similar to [2]. We focus on the simultaneous optimization of end-to-end efficiency and signal-to-noise level in the memory, and have achieved light storage at the single-photon level with end-to-end efficiencies up to 12%. Simultaneously we achieve a minimal noise level corresponding to $\bar{\mu}_1 = 0.029$ signal photons. Furthermore, we have determined the limiting noise source at this level to be four-wave mixing in the $\Lambda$-system and present solutions to minimize this read-out noise.

[1] M. Gündoğan et al., npj Quantum Information 7, 128 (2021)
[2] J. Wolters, et al., PRL 119, 060502 (2017)

Q 35.7 Wed 15:30 Q-H12

**Integrated photonics for quantum communications on a CubeSat** — •Jonas Pudelko[1,2], Ömer Bayraktar[1,2], Imran Khan[1,2], Winfried Boxleitner[3], Stefan Petscharnig[3], Christoph Pacher[3], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Institute of Optics, Information and Photonics, Friedrich-Alexander University Erlangen-Nürnberg, Germany — [3]AIT Austrian Institute of Technology GmbH, Center for Digital Safety & Security, Vienna, Austria

The limited range of quantum key distribution (QKD) in fiber based systems led to several projects aiming for the development of a satellite based QKD infrastructure. Photonic integrated circuits (PICs) are a convenient way to implement all necessary optical functions for QKD, while meeting the stringent demands on size, weight and power in satellite missions.

In this work, we present our payload intended for the demonstration of integrated quantum communication technology in space. It is based on two Indium-Phosphide PICs implementing a source for modulated weak coherent states as well as a quantum random number generator (QRNG) based on homodyne measurements of the quantum mechanical vacuum state. The whole system is implemented on a 10 cm x 10 cm PCB including electronics, making it compatible to the CubeSat standard.

These developments will be tested as a part of the CubeSat mission QUBE, which is scheduled for launch in 2022.

Q 35.8 Wed 15:45 Q-H12

**Free-space continuous-variable quantum key distribution using discrete modulation** — •Kevin Jaksch[1,2], Thomas Dirmeier[1,2], Yannick Weiser[1,2], Stefan Richter[1,2], Ömer Bayraktar[1,2], Bastian Hacker[1,2], Conrad Rössler[1,2], Imran Khan[1,2], Andrej Krzic[3], Teresa Kopf[3], René Berlich[3], Matthias Goy[3], Daniel Rieländer[3], Fabian Steinlechner[3], Florian Kanitschar[4], Stefan Petscharning[4], Thomas Grafenauer[4], Ömer Bernhard[4], Christoph Pacher[4], Twesh Upadhyaya[5], Jie Lin[5], Norbert Lütkenhaus[5], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Friedrich Alexander University Erlangen-Nürnberg, Germany — [3]Fraunhofer Institute for Applied Optics and Precision Engineering, Jena, Germany — [4]AIT Austrian Institute of Technology, Center for Digital Safety&Security, Vienna, Austria — [5]Institute for Quantum Computing and Department of Physics and Astronomy, University of Waterloo, Canada

In future metropolitan quantum key distribution (QKD) networks, point-to-point free-space links will allow to secure the communication beyond the existing but inflexible fiber backbone. For this purpose, we investigate a continuous-variable QKD system using a discrete modulation pattern in the polarization degree of freedom. We present our results obtained in an experiment over an urban 300m free-space link between the Federal Ministry of Education and Research (BMBF) and the Federal Office for Information Security (BSI) in Bonn.