FM 77: Quantum Networks: Platforms and Components II

Time: Thursday 14:00–15:45 Location: 1098

Invited Talk FM 77.1 Thu 14:00 1098

Integrating Quantum Key Distribution into Telecom Networks — •James Dynes — Toshiba Research Europe Limited, Cambridge, United Kingdom

Quantum Key Distribution (QKD) is one of the most mature applications of quantum physics to move out of the laboratory. Over the past fifteen years, there has been much progress in maturing QKD technology. In particular, field demonstrations of quantum key distribution (QKD) are an important step towards successful, full scale commercialization of QKD. In this talk we will report on recent progress of incorporating QKD with conventional telecom networks within the UK, thus paving the way towards building large scale commercial QKD networks.

FM 77.2 Thu 14:30 1098

Quantum Information Applications with Single Defect Centers in 4H-SiC — •Florian Kaiser, Naoya Morioka, Roland Nagy, Matthias Niethammer, Izel Gediz, Erik Hesselmeier, Charles Babin, Matthias Widmann, Yu-Chen Chen, Roman Kolesov, Rainer Stöhr, and Jörg Wrachtrup — 3rd Institute of Physics, University of Stuttgart and IQST, Stuttgart, Germany

Silicon carbide (SiC) is the gold standard material for high power electronics thanks to outstanding thermal conductivity, breakdown voltage, and a large bandgap energy.

Recently, the SiC platform has also been identified to be very promising for quantum information distribution tasks [1]. In this regard, a critical requirement is stable optical emission of indistinguishable photons through which multiple spintronics systems can be reliably entangled via optical interference [2].

Here, we will show our recent efforts in measuring two-photon indistinguishability of single V1 centres in 4H-SiC via Hong, Ou and Mandel interference. Our results show that the V1 centre in 4H-SiC is a prime candidate for realising memory-assisted quantum network applications using semiconductor-based spin-to-photon interfaces and coherently coupled electron/nuclear spins.

We will additionally discuss near-term reachable network scenarios, and achievable performance parameters.

[1] R. Nagy et al., Nat. Commun. 10, 1954 (2019)
[2] F. Rozpedek et al., Phys. Rev. A 99, 052330 (2019)

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Quantum networking tools with single atoms and single photons — •Stephan Kucera, Pascal Eich, Matthias Bock, Matthias Kreis, Jan Arenskötter, Christoph Becher, and Jürgen Eschner — Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken

In the context of quantum communication technologies, we are developing a comprehensive set of experimental tools, based on single photons and single atoms (trapped ions), that enable controlled generation, storage, transmission, and conversion of photonic qubits in quantum networks in a programmable manner [1,2]. As experimental applications, we demonstrate high-fidelity transfer of entanglement from a narrowband SPDC photon pair to atom-photon pairs, as well as atom-to-photon qubit teleportation [3]. We also extend our quantum network toolbox into the telecom regime by polarization-preserving quantum frequency conversion of atom-entangled photons [4].

[1] C. Kurz et al., Nat. Commun. **5**, 5527 (2014)
[2] C. Kurz et al., Phys. Rev. A **93**, 062348 (2016)
[3] S. Kucera et al., in preparation
[4] M. Bock et al., Nat. Commun. **9**, 1998 (2018)

FM 77.4 Thu 15:00 1098

Evaluation of Volume Bragg Gratings as a Wavelength Division Multiplexer in Entanglement-Based Free-Space Quantum Link — •Riza Fazili[1] and Fabian Steinlechner[2] — [1]Friedrich-Schiller University Jena, Abbe School of Photonics, Albert-Einstein-Str. 5, 07745 Jena, Germany — [2]Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany

It has been shown that wavelength division multiplexing (WDM) is feasible in quantum key distribution (QKD) and has many advantages such as raising the key generation rate. Whereas all the previous attempts of multiplexing in quantum communication have been via optical fibers, a WDM in free-space quantum links can play a more crucial role due to technical challenges in particular the limited time window of the satellite-ground communication. Here, we report on designing and implementing the first low-loss WDM in entanglement-based free-space QKD using volume Bragg gratings (VBGs) at ~800 nm. The total insertion loss for two channels is 0.6 dB which matches the state of the art at telecommunication wavelengths (~1550 nm) and surpasses any known WDMs at ~800 nm. The low cross talk of 20 dB in 0.3 nm in our WDM, unleash the potential of having many channels in a given entangled photons spectrum. We demonstrate that our WDM could operate under turbulence effects and the insertion loss is ~0.6 dB for weak and ~2 dB for strong turbulences. This ability would simplify the coupling procedure at the receiving telescope and can be a game changing factor in the future of free-space QKD.

FM 77.5 Thu 15:15 1098

Ultra-compact and ultra-bright photon-pair source for QKD — •Emma Brambila[1,2], Fabian Steinlechner[1], and Markus Gräfe[1] — [1]Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Straße 7, 07745 Jena, Germany. — [2]Friedrich-Schiller University Jena, Abbe School of Photonics, Albert-Einstein-Str. 5, 07745 Jena, Germany.

Polarization entangled photon pairs are the major ingredient for various quantum technology applications, in particular for quantum key distribution (QKD). There, compact, stable, and very bright entangled photon pairs sources (EPS) are demanded for field deployment. Only by providing reliable EPS as user-friendly hardware components, QKD can be commercialized and applied for society outside research lab facilities.

In this work, we present a prototype lab-version of a compact, simplified, highly stable, and ultra-bright EPS. The polarization entangled photon pair source is based on a type-0 phase matched ppKTP crystal in a Sagnac-loop, which is pumped at 405 nm. The EPS is fully fiber coupled and designed as turn-key system. We are going to present data on its characterization like fidelity, spectral distribution of signal and idler photons, and the heralding efficiency.

FM 77.6 Thu 15:30 1098

Interfacing single Erbium ions with photons at telecom wavelength — •Benjamin Merkel, Pablo Cova Fariña, Alexander Ulanowski, Lorenz Weiss, Andreas Gritsch, and Andreas Reiserer — MPI of Quantum Optics, Garching, Germany

Global quantum networks will require efficient interfaces between long-lived memory nodes and photons at a telecommunications wavelength, where loss in optical fibers is minimal. In this context, individual Erbium ions doped into suited crystals are a promising candidate, as they exhibit both an optical transition at 1.5 μm and spin lifetimes exceeding 100 ms. Unfortunately, the long lifetime of the optical transition ($\simeq$ 10 ms) limits the fluorecence rate and makes it difficult to spectrally resolve and control single ions.

We study different approaches to overcome this limitation: First, we have assembled high-finesse cavities which will lead to an expected 200-fold reduction of the lifetime. We have stabilized their resonance frequencies to a fraction of a linewidth, i.e. to the sub-pm-level, despite the abundance of mechanical vibrations in a closed-cycle cryostat environment. Second, as a first step towards on-chip quantum network nodes, we try to combine Erbium ions with Silicon nanophotonic waveguides and photonic crystal cavities [1]. We will present the current status of the mentioned experiments.

[1] A. M. Dibos et al., Phys. Rev. Lett. 120, 243601 (2018)