Symposium Quantum Communication: Promises or Reality? (SYQC)

jointly organized by
the Semiconductor Physics Division (HL),
the Low Temperature Physics Division (TT), and
the Quantum Information Division (QI)

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Quantum communication holds immense promises in revolutionizing secure information transfer and has captivated researchers and industry professionals worldwide. At its core lies quantum key distribution (QKD), an influential technique that harnesses the fundamental principles of quantum mechanics to enable secure key exchange. The success of quantum communication hinges on the availability of single or entangled photons, which can be generated through processes such as spontaneous parametric down conversion or on-demand from solid-state quantum emiters. However, to bring quantum communication into practical real-world applications, it is imperative to optimize and control the photon generation process. Moreover, the efficient transmission and reception of the quantum signals must be seamlessly integrated into advanced photonic structures, ushering in a new era of secure and efficient communication.

Overview of Invited Talks and Sessions

(Lecture hall H 0105)

Invited Talks

SYQC 1.1	Fri	9:30–10:00	H 0105	**Efficient Quantum Dot Micropillars for Quantum Networks** — David Dlaka, Petros Androvitsaneas, Andrew Young, Qirui Ma, Edmund Harbord, •Ruth Oulton
SYQC 1.2	Fri	10:00–10:30	H 0105	**Superconducting Single Photon Detectors - Limited only by the laws of physics** — •Andreas Fognini
SYQC 1.3	Fri	10:45–11:15	H 0105	**Laser triggering of quantum light sources using engineered optical pulses** — •Kimberley Hall
SYQC 1.4	Fri	11:15–11:45	H 0105	**Quantum Networks and Technologies** — •Rob Thew

Sessions

SYQC 1.1–1.4	Fri	9:30–13:00	H 0105	**Quantum Communication: Promises or Reality?**

SYQC 1: Quantum Communication: Promises or Reality?

Time: Friday 9:30–13:00 Location: H 0105

Invited Talk SYQC 1.1 Fri 9:30 H 0105

Efficient Quantum Dot Micropillars for Quantum Networks — David Dlaka[1], Petros Androvitsaneas[2], Andrew Young[1], Qirui Ma[1], Edmund Harbord[1], and •Ruth Oulton[1] — [1]Quantum Engineering Technology Labs, H. H. Wills Physics Laboratory and School of Electrical, Electronic and Mechanical Engineering, University of Bristol, UK — [2]School of Engineering, Queens Buildings, Cardiff University

Quantum dot micropillars are an established device technology for producing on-demand single photons, entangled pair photons, cluster states and non-linear interactions such as photon number sorting and spin-based switching. I will present the prospects for quantum dot micropillars as near-perfect devices for single and pair photon sources and non-linear interactions.

I will present designs of low Q-factor micropillar cavities that show exceptional figures of merit: $>$ 95% overall efficiency for moderate Q-factor of 2500. Such cavities have an inherent phonon sideband suppression of over an order of magnitude, which gives the potential for single photon indistinguishabilities of $>$0.99. These low Q-factor designs are undemanding to manufacture compare to other very high brightness designs proposed, and promise the prospect of using QDs widely as sources, switches and cluster state generators. The spectrally broad cavity is also capable of supporting high brightness biexciton cascade entangled pair sources: pair efficiencies of 75% are possible and the broad cavity shows no linear mode splitting that would otherwise destroy the polarization entanglement of the pair.

Invited Talk SYQC 1.2 Fri 10:00 H 0105

Superconducting Single Photon Detectors - Limited only by the laws of physics — •Andreas Fognini — Single Quantum, Rotterdamseweg 394, 2629 HH Delft, The Netherlands

In recent years, the demand for ultrasensitive, high-performance single-photon detectors in the telecom range has led to significant advancements in superconducting nanowire single-photon detectors (SNSPDs). These detectors operate at about 2.5 Kelvin and detect a single-photon by a quantum phase change from the superconducting- to a resistive state. The benefits of SNSPDs are the ability to detect single-photons at the 1550 nm telecom wavelength and beyond with extremely low dark-counts in the Hz regime, while providing very low jitter on the order of 15 ps.

The landscape for SNSPDs is changing rapidly: Ten years ago, SNSPDs were only used in academic research; now, SNSPDs are becoming more widely adopted and are finding more industrial applications. Especially the large funding provided for QKD is accelerating the industrialization and bringing the technology slowly into datacenters.

From this rapid development also other SNSPD applications are profiting through the involved standardizations and enhanced market acceptance like bio-imaging, material science, and even deep-space communication.

In this talk, I want to showcase the rapid developments in SNSPD technology and its applications which have been achieved in the field over the last 10 years.

15 min. break

Invited Talk SYQC 1.3 Fri 10:45 H 0105

Laser triggering of quantum light sources using engineered optical pulses — •Kimberley Hall — Dalhousie University, Halifax, Nova Scotia Canada B3H 4R2

Emerging quantum technologies such as photonic quantum computers, quantum cryptography, and quantum imaging require sources of single and/or entangled photons that may be triggered on demand. Solid-state quantum emitters based on semiconductor quantum dots offer the potential for integration into scalable photonic platforms and possess high radiative quantum efficiencies and strong optical transitions. Femtosecond pulse shaping provides a highly flexible approach to tailoring optically mediated quantum gates involving solid-state qubit and quantum emitter systems. In this talk, I will highlight the tools and methods associated with optimal quantum control and describe our application of these techniques to the parallel driving of emitters for the multiplexing of quantum light sources [1]. A new laser driving scheme developed by our group for triggering single photon emitters will also be described [2]. [1] A. Ramachandran et al. Robust parallel laser driving of quantum dots for multiplexing of quantum light sources, arXiv/2203.01385 (2023). [2] G. R. Wilbur et al. Notch-filtered adiabatic rapid passage for optically driven quantum light sources, APL Photonics 7, 111302 (2022).

Invited Talk SYQC 1.4 Fri 11:15 H 0105

Quantum Networks and Technologies — •Rob Thew — University of Geneva, Switzerland

We will briefly highlight some recent experiments and developments for quantum communication and the associated technologies for deploying quantum systems. Firstly, we'll look at how integrated photonics is being used in QKD systems, before moving to entanglement-based systems for quantum repeater architectures. We will then discuss some recent advances for photon number resolving detectors as well as integrated photonics technologies being developed for quantum repeaters. We will finish with some perspectives on interesting future directions and challenges.

15 min. break

12:00 Panel discussion with all invited speakers and organizers (until 13:00).