

Advancing Photonic Quantum Technologies by Bridging Quantum Optics & Quantum Information Science

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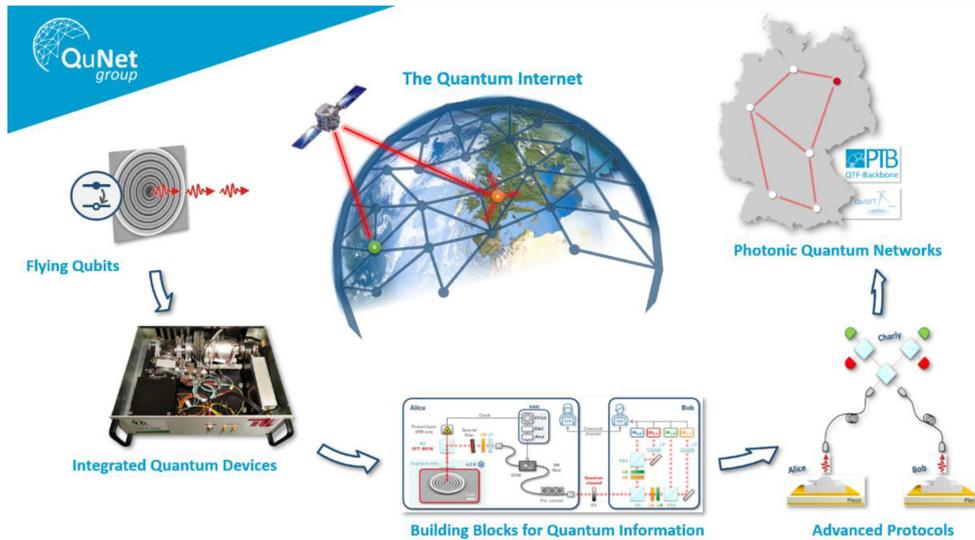


Figure 1: Advances towards a global quantum internet require research in multiple fields ranging from solid-state quantum optics to quantum information science.

Tremendous progress has been achieved in the field of quantum information and photonic quantum technologies. In this context, the generation and precise control of qubits, whether photonic or embedded in the solid-state, lies at the heart of groundbreaking applications holding the potential to transform our society. Our Department for Quantum Technology aims to play an important role in this endeavour. Against this background, I will review recent advances at the intersection of the fields of solid-state quantum optics and quantum information technology, ultimately striving towards quantum networking at the global scale [1] (see also Figure 1).

One focus will be on the recent advances in quantum light generation using quantum dot devices based on hybrid circular Bragg gratings (hCBG) enabling high-speed quantum optics experiments at clock-rates beyond 1 GHz, both at wavelengths around 930 nm [2] and 1550 nm [3]. Using numerically optimized microcavity designs in combination with precise fabrication technologies, high Purcell enhancements can be realized experimentally resulting in emitter lifetimes well below μ 100 ps in both spectral ranges. Combined with direct fiber-coupling technologies, such devices enable the generation of indistinguishable photons at GHz-clock rates in server-rack compatible demonstrators [4]. In the context of quantum light generation, I will also highlight the award-winning science communication project QuanTour [5], in which a quantum light source from my group, travelled across the world.

Aiming for applications, we employ our high-Purcell single-photon sources in experiments demonstrating the first quantum cryptographic primitive beyond QKD [6], which has important implications for distrustful network settings. Experimentally implementing a quantum strong coin flipping (QSCF) protocol at 80 MHz clock-rate, we demonstrate an advantage compared to both, classical realizations and implementations using faint

laser pulses. We achieve this by employing a fast polarization-state encoding with a quantum bit error ratio below 3%, required for the successful execution of this protocol type. Demonstrating a quantum advantage of 1.6%, our work represents an important step forward in exploiting quantum advantages in realistic quantum network settings.

Finally, I will close my talk by giving an overview about current developments in the Department for Quantum Technology, including perspectives for upcoming projects and future perspectives.

[1] D. A. Vajner et al., *Advanced Quantum Technologies*, 2100116 (2022)

[2] L. Rickert et al., *ACS Photonics* 12, 464–475 (2025)

[3] R. Behrends et al., manuscript in preparation (2025)

[4] L. Rickert et al., *Nanophotonics*, doi:10.1515/nanoph-2024-0519 (2025)

[5] R. Sender, The travels of a quantum light source, *Optics & Photonics News* 36, Dec. 2025

[6] D. A. Vajner et al., arXiv:2412.14993 (2024)