## From Applied Laser Science to a City-Scale Quantum Key Distribution Network

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The research projects pursued in my group range from applications such as the temperature profile measurement in the ocean, laser spectroscopy and laser development to fundamental topics in quantum optics and quantum technologies. After a brief overview on these projects, I will focus on our work in Quantum Key Distribution (QKD).

QKD is one of the possible solutions to maintain data privacy when quantum computers will render today's public-key cryptography insufficient. For a broad deployment of QKD, scalable and robust systems are necessary. Scalability can be achieved by using star-shaped networks in combination with entanglement-based QKD protocols. A single untrusted source in the center serves all connected network parties to exchange keys. We implemented a time-bin variant of the BBM92 protocol and demonstrated simultaneous pairwise QKD between four users while maintaining a principal scaling to up to 100 users.

The critical components are interferometers in the source and each receiving party. Longand short term stabilization of our interferometers is achieved by controlling the interferometer temperature with sub-millikelvin resolution. Based on our prior works [1-3], we distributed our receiver units among four labs within Darmstadt and connected them via deployed fibers operated by Deutsche Telekom and TU Darmstadt. Furthermore, we implemented post-quantum secure authentication schemes for the public channel as well as full error correction, privacy amplification and software based clock recovery. In our talk, we discuss our results and give an outlook on future work, where we plan to switch to a Photonic Chip based photon source.

- [1] <u>E. Fitzke et al., PRX 3 (2022) 020341;</u>
- [2] T. Dolejsky et al. Europ. Phys. J. Spec. Top. 232 (2023) 3553;
- [3] J. Kaltwasser et al., Physical Review A 109 (2024) 012618;



Figure: Schematic Overview of our star-shaped network with four parties (left) and photograph of our photonic chip (right).