FM 27: Special Session: Quantum Networks

Time: Tuesday 11:00–13:00 Location: Audi Max

Invited Talk FM 27.1 Tue 11:00 Audi Max

Frontiers in quantum acoustics — •Andrew Cleland — Pritzker School of Molecular Engineering, University of Chicago Chicago IL 60637 USA

Superconducting qubits provide unique opportunities as a testbed for quantum communication as well as developing hybrid quantum systems. Here, I will discuss applications for superconducting qubits in generating and detecting individual phonons, in the form of surface acoustic wave (SAW) excitations, and using these phonon states to generate remote quantum entanglement. Specifically, I will describe recent experiments [1,2] where we have demonstrated the use of reasonably high finesse acoustic Fabry-Perot structures to store acoustic phonon Fock states, in which we can measure the Wigner tomograms of individual Fock states as well as their superpositions. In more recent work, we have coupled two superconducting qubits to a long SAW resonator with a 500 ns phonon bounce time. We can release and recapture individual itinerant phonons using one of the two qubits, as well as transfer quantum states between the two qubits.

In this talk, I will introduce the superconducting qubits we use for these experiments, explain details of how the acoustic systems are integrated with the qubits, and describe how we use the qubits to achieve quantum control over acoustic phonons.

[1] K. J. Satzinger et al., "Quantum control of surface acoustic wave phonons", Nature 563, 661-665 (2018). [2] A. Bienfait et al., "Phonon-mediated quantum state transfer and remote qubit entanglement", Science 364, 368-371 (2019).

Invited Talk FM 27.2 Tue 11:30 Audi Max

The state of the art of quantum key distribution. — •Hugo Zbinden — University of Geneva, Switzerland

I will give a short introduction into Quantum Key Distribution, which could play an important role in future secure communications. Some experimental challenges, in particular for QKD over long distances and at high rates are discussed. I will present a recent experiment of QKD over 400km of optical fibre and options for increasing this distance using quantum repeaters or satellites.

Invited Talk FM 27.3 Tue 12:00 Audi Max

Towards Quantum Communication Networks using Solid-State Quantum-Light Sources — •Tobias Heindel — Institute of Solid-State Physics, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

Tremendous progress has been achieved in the engineering of solid-state-based non-classical light sources during the last two decades. In this context, quantum-light sources based on semiconductor quantum dots (QDs) are of particular interest. Allowing for the generation of close-to-ideal flying qubits these devices are predestinated for implementations of quantum communication.

In my talk, I will review our progress in this field, striving towards the ultimate goal of a global secure communication. I will revisit proof-of-concept quantum key distribution (QKD) experiments [1] and discuss the development of state-of-the-art components for QKD, such as plug-and-play single-photon sources and receiver modules. In this framework, we show how to optimize the performance of QKD implementations and demonstrate real-time security monitoring for QKD with sub-poissonian light sources [2]. Assembling these building blocks to build functional multi-user quantum-secured communication networks will be a grand challenge in photonic quantum technologies, which is tackled within my recently founded Junior Research Group at Technische Universität Berlin.

[1] T. Heindel et al., New J. Phys. 14, 083001 (2012)
[2] T. Kupko et al., in preparation (2019)

Invited Talk FM 27.4 Tue 12:30 Audi Max

Towards quantum networks based on single trapped atoms — •Wenjamin Rosenfeld — Ludwig-Maximilians-Universität, München — Max-Planck-Institut für Quantenoptik, Garching

Quantum networks hold promise for enabling secure communication and distributed quantum computing. In this context, single trapped atoms represent a mature platform featuring a high level of control of internal and external degrees of freedom, long coherence times and reliable coupling to photonic channels. These features recently enabled distribution of entanglement between single atoms over macroscopic distances [1] and certification of its properties allowing for applications in an elementary quantum network link [2].

Current work is focused on extending the distance of entanglement distribution. Since the ground-state optical transitions in atoms are typically in the visible or near-infrared regime, for efficient long-distance transport of photons over optical fibers quantum frequency conversion into telecom wavelength range is required. Based on a non-linear conversion process, this method was already successfully demonstrated for trapped ions [3] and is now being developed for the neutral atom platform. First measurements show a promising capability for distributing entanglement over few tens of kilometers - a realistic distance for implementing an elementary link of a quantum repeater.

[1] W. Rosenfeld *et al.*, Phys. Rev. Lett., **119**, 010402 (2017).
[2] J.-D. Bancal *et al.*, arXiv:1812.09117 [quant-ph] (2018).
[3] M. Bock *et al.*, Nature Communications **9**, 1998 (2018)