# A 12: Quantum Repeaters SYQR 2 (with Q)

Time: Monday 14:00–16:00 Location: Audimax

**Invited Talk** A 12.1 Mon 14:00 Audimax
**Protocols and prospects for building a quantum repeater** — •Peter van Loock — Institute of Physics, Johannes Gutenberg Universität Mainz, Germany

An overview will be given of various approaches to implementing a quantum repeater for quantum communication over large distances. This includes a discussion of systems and protocols that are experimentally feasible and thus realizable in the midterm in order to go beyond the current limit of a few hundred km given by direct quantum-state transmissions. At the same time, these schemes should be, in principle, scalable to arbitrary distances. In this context, the influence of various elements and strategies in a quantum repeater protocol on the final fidelities and rates shall be addressed: initial entanglement distribution, Bell measurements, multiplexing, postselection, quantum memories, and quantum error detection/correction. Solely on the hardware side, the differences in using just single quanta or instead employing many quanta for the flying (photons) and the stationary (atoms) qubits will be pointed out.

**Invited Talk** A 12.2 Mon 14:30 Audimax
**Quantum teleportation from a telecom-wavelength photon to a solid-state quantum memory** — •Felix Bussieres — Group of Applied Physics, University of Geneva, Switzerland

Quantum teleportation is a cornerstone of quantum information science due to its essential role in several important tasks such as the long-distance transmission of quantum information using quantum repeaters. In this context, a challenge of paramount importance is the distribution of entanglement between remote nodes, and to use this entanglement as a resource for long-distance light-to-matter quantum teleportation. In this talk I will report on the demonstration of quantum teleportation of the polarization state of a telecom-wavelength photon onto the state of a solid-state quantum memory. Entanglement is established between a rare-earth-ion doped crystal storing a single photon that is polarization-entangled with a flying telecom-wavelength photon. The latter is jointly measured with another flying qubit carrying the polarization state to be teleported, which heralds the teleportation. The fidelity of the polarization state of the photon retrieved from the memory is shown to be greater than the maximum fidelity achievable without entanglement, even when the combined distances travelled by the two flying qubits is 25 km of standard optical fibre. This light-to-matter teleportation channel paves the way towards long-distance implementations of quantum networks with solid-state quantum memories.

**Invited Talk** A 12.3 Mon 15:00 Audimax
**Semiconductor quantum light sources for quantum repeaters** — •Peter Michler — Universität Stuttgart, Institut für Halbleiteroptik und Funktionelle Grenzflächen, Germany

Exploiting the quantum properties of light has the potential of enabling many new applications in the field of photonics and quantum information technology, such as secure communication, imaging and lithography techniques beyond the diffraction limit, quantum repeaters as well as photonic quantum computing. Many of these applications require the generation of on demand indistinguishable single photons or entangled photon pairs. Resonantly excited single semiconductor quantum dots are perfectly suited to fulfill these requirements. In my talk, I will discuss the fascinating physic as well as the current status of such resonantly driven semiconductor light sources.

**Invited Talk** A 12.4 Mon 15:30 Audimax
**Quantum networks based on cavity QED** — •Stephan Ritter, Joerg Bochmann, Eden Figueroa, Carolin Hahn, Norbert Kalb, Martin Mücke, Andreas Neuzner, Christian Nölleke, Andreas Reiserer, Manuel Uphoff, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Quantum repeaters require an efficient interface between stationary quantum memories and flying photons. Single atoms in optical cavities are ideally suited as universal quantum network nodes that are capable of sending, storing, retrieving, and even processing quantum information. We demonstrate this by presenting an elementary version of a quantum network based on two identical nodes in remote, independent laboratories. The reversible exchange of quantum information and the creation of remote entanglement are achieved by exchange of a single photon. Quantum teleportation is implemented using a time-resolved photonic Bell-state measurement. Quantum control over all degrees of freedom of the single atom also allows for the nondestructive detection of flying photons and the implementation of a quantum gate between the spin state of the atom and the polarization of a photon upon its reflection from the cavity. Our approach to quantum networking offers a clear perspective for scalability and provides the essential components for the realization of a quantum repeater.