**SPECIAL QUANTUM ENGINEERING SEMINAR**
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**CU Engineering, DLC 1B70**

# Quantum memories and sensors based on neutral atoms

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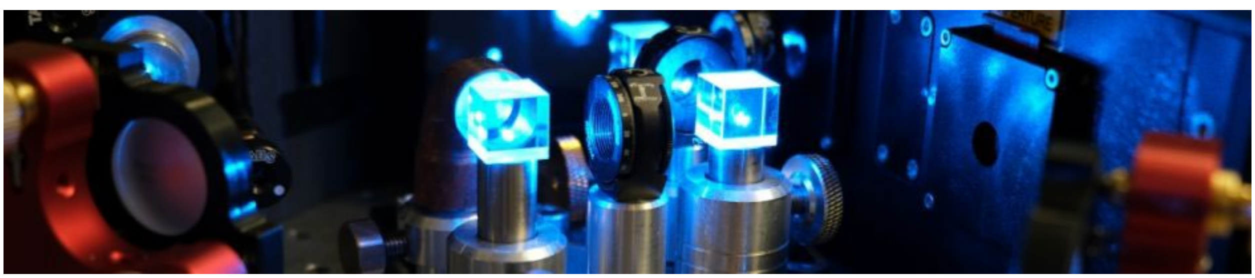
Neutral atoms are one of the established platforms for studying quantum physics. This talk reviews the related topics which hold promise to contribute to quantum technologies. Optical quantum memories based on atomic ensembles traditionally allow for storage and retrieval of light. It has been a long-standing challenge to design memories that will allow efficient and low-noise storage of photons, in particular in many modes. With many modes we may parallelize operation of the memory with many channels or use qudits, leading to different features. The multiplexing methods may employ spectral-temporal modes or spatial modes, which we have learned to control in our memory. Furthermore, between the storage and retrieval we have also introduced a processing phase with mode-transforming linear operations within the memory. More recently, we have also used the memory for sensing of external magnetic fields via ground-state coherence. By combining it with memory, we demonstrate 3D tomography of the magnetic field. However, the sensitivity to external fields with neutral atoms is particularly impressive for microwaves field resonant to Rydberg transitions. I will present our two recent experiments with Rydberg atoms, where we have used a six-wave mixing process to coherently upconvert microwave photons to the near-infrared. Our two demonstrations focus on phase-insensitive detection at the single-photon level, where second-order correlation of thermal background radiation may be observed, and secondly the phase-sensitive detection with homodyning. The phase-sensitive detection along with several modifications has allowed us to demonstrate all-optical operation of the Rydberg-atom superheterodyne receiver (i.e. without a microwave LO).



**Dr. Michał Parniak-Niedojadło** is a junior group leader in the Centre for Quantum Optical Technologies QOT. His research interests cover a range of topics in quantum optics, such as single photon detection, optical quantum information processing and communication, atomic ensembles, nonlinear optics and quantum opto-mechanics. Within QOT he develops experimental implementations of quantum protocols designed by the theory groups and maintains close experimental collaboration with prof. Wojciech Wasilewski (QOT) and prof. Eugene Polzik (Niels Bohr Institute, University of Copenhagen). His most significant scientific achievements include demonstrating superresolution in imaging using two-photon interference, demonstrating the record-breaking quantum memory in terms of its capacity, and demonstration of the first entanglement of macroscopic spin and mechanical systems.

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