University of Basel

Swiss Nanoscience Institute

Swiss Nanoscience Institute
Center of Excellence supported by the University of Basel and the Canton of Aargau

Coherent feedback control of nanomechanical oscillators

Prof. Dr. Philipp Treutlein, Department of Physics, University of Basel, Switzerland (Main PI)
Prof. Dr. Patrick Potts, Department of Physics, University of Basel, Switzerland (Co-PI)

The project:
Feedback is a powerful control technique in the classical and quantum domain. The conventional strategy relies on performing a measurement, classical (usually electronic) signal processing, and feedback to an actuator on the system. However, when applied to quantum systems, the measurement disturbs the quantum state, resulting in measurement back-action and decoherence. A different kind of feedback is possible: *coherent feedback* of *quantum signals* that are processed quantum mechanically and actuate the system without any intervening measurement. This approach raises interesting conceptual questions and promises new control techniques for quantum systems.

The Treutlein group (experiment) and Potts group (theory) recently reported the first demonstration of coherent feedback control in optomechanics [M. Ernzer et al, PRX 13, 021023 (2023)], demonstrating cooling of the mechanical oscillator close to its quantum mechanical ground state. In this PhD project, we will go an important step further and explore coherent feedback in the quantum regime. Indeed, various coherent feedback protocols have been theoretically proposed that could enable or enhance squeezing, entanglement generation, verification, as well as quantum state transfer and precision measurements. We will further develop and experimentally realize these concepts for the first time.

Our experiments employ a cryogenic cavity optomechanical setup involving a SiN membrane oscillator with a phononic crystal structure, see Figure. Such membrane oscillators feature vibrational modes of extremely high mechanical quality factors exceeding 10^8 and at the same time have excellent optical properties, making them an ideal system for quantum optomechanics experiments.

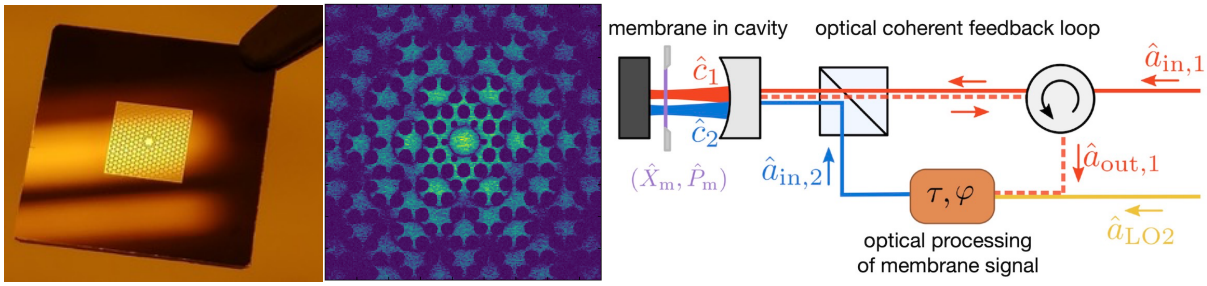

***Figure**: SiN membrane oscillator with phononic crystal structure (left) and image of a vibrational mode in the central defect (middle). Coherent feedback scheme for quantum control of the membrane (right).*

We offer the possibility to do exciting experiments in a lively team in an international environment. Our laboratories are well-equipped for quantum optics and nanomechanics experiments at the forefront of research and we benefit from collaborations with excellent theory groups.
Our institute is located in the city centre of Basel – a truly international city of manageable size, with a very high quality of life and a rich variety of scientific, sporting, and cultural activities.

Your profile: We expect strong motivation and commitment to research, a very good understanding of physics and a talent for building and conducting experiments.
A physics master's degree or equivalent is mandatory and previous experience in the field of experimental quantum optics, optomechanics or atomic physics is highly desired.

Contact and further information:
Prof. Dr. Philipp Treutlein (philipp.treutlein@unibas.ch), https://atom.physik.unibas.ch