PhD project at the Swiss Nanoscience Institute, University of Basel, Switzerland

Cooling and control of a nanomechanical membrane with cold atoms

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Project description

This PhD project focuses on experimental research at the intersection of the vibrant fields of optomechanics[1] and ultracold atoms[2]. The goal is to realize a hybrid quantum system in which laser-cooled atoms are strongly coupled to the vibrations of a nanomechanical membrane in an optical cavity. Laser light will provide a long-distance coupling between the two systems, enabling a modular setup where the membrane-cavity system is placed in a cryostat while the atoms are prepared in a separate room-temperature vacuum chamber. In a recent theory paper[3], we have shown that ground-state cooling of the membrane and strong atom-membrane coupling are achievable in this system.

The goal of this PhD project is to implement the system described in ref. 3 and to use it for experiments on cooling and control of mechanical motion. The demonstration of a strongly coupled atom-oscillator system would be an important achievement. Mechanical oscillators in the quantum regime offer new perspectives for precision force sensing, the realization of quantum transducers, and tests of quantum mechanics in massive systems.

The Treutlein group at the University of Basel has pioneered hybrid atom-mechanical oscillator experiments[4]. We have recently built a new experimental setup that allows us to prepare ultracold atoms in an optical trap and couple the atoms to a membrane in a separate room-temperature vacuum chamber. As part of this PhD project, the setup will be upgraded to allow coupling of atoms to a cryogenically precooled membrane, an essential step towards ground-state cooling and quantum control. Different types of membranes will be explored in collaboration with the group of Prof. P. Maletinsky (Basel). Moreover, this project involves a collaboration with the group of Prof. P. Zoller (University of Innsbruck, Austria), with whom we developed the theory of our system[3].

Requirements

We are looking for a highly motivated and experimentally talented PhD student to join our group at the Department of Physics of the University of Basel. You should hold a master's degree or equivalent in physics or nanoscience and ideally have prior experience in optomechanics, quantum optics, or ultracold atom experiments. Excellent candidates with a different background will be considered as well. You will work in an international team of 2-4 people on a cutting edge experimental apparatus.

For more information, see our group homepage at http://atom.physik.unibas.ch

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[1] For a review, see M. Aspelmeyer, T. J. Kippenberg, and F. Marquardt, arXiv:1303.0733 (2013).
[2] For a review, see S. Chu, *Cold atoms and quantum control*, Nature 416, 206 (2002).
[3] B. Vogell, K. Stannigel, P. Zoller, K. Hammerer, M. T. Rakher, M. Korppi, A. Jöckel, and P. Treutlein, *Cavity-enhanced long-distance coupling of an atomic ensemble to a micromechanical membrane*, Phys. Rev. A 87, 023816 (2013).
[4] S. Camerer, M. Korppi, A. Jöckel, D. Hunger, T. W. Hänsch, and P. Treutlein, *Realization of an optomechanical interface between ultracold atoms and a membrane*, Phys. Rev. Lett. 107, 223001 (2011).