Observation of bi-directional coupling between ultracold atoms and a mechanical oscillator

Stephan Camerer,[1,2] Maria Korppi,[1,2,3] Andreas Jöckel,[1,2,3]
David Hunger,[1,2] Theodor W. Hänsch,[1,2] and Philipp Treutlein[1,2,3]

[1]Max-Planck-Institute of Quantum Optics, Garching, Germany
[2]Faculty of Physics, Ludwig-Maximilians-University Munich, Germany
[3]Department of Physics, University of Basel, Switzerland
E-mail: philipp.treutlein@unibas.ch Homepage: www.atom.physik.unibas.ch

Abstract

We report the observation of bi-directional coupling between a mechanical oscillator and the center-of-mass motion of ultracold atoms. Our experiment realizes a recently proposed system [1] in which an optical lattice mediates a long-distance coupling between laser-cooled atoms and a micromechanical membrane. We detect both the effect of the vibrating membrane onto the atoms as well as the effect of the atoms onto the membrane and find reasonable agreement with a simple theoretical model. Coupling ultracold atoms to mechanical oscillators opens the exciting perspective of using the tools of atomic physics to read out, cool, and coherently manipulate the oscillators' state [2, 3].

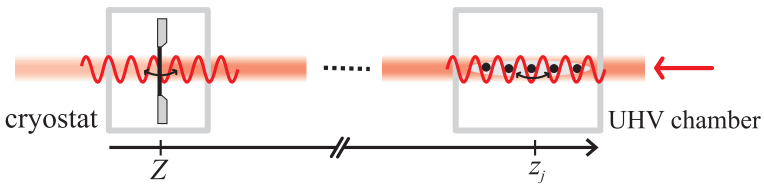

Figure 1: Schematic of our setup: A laser field impinging from the right is partially reflected off a dielectric membrane and forms a standing wave optical potential for an atomic ensemble. Vibrations of the membrane's fundamental mode will shift the standing wave field, shaking atoms in the optical lattice. Conversely, oscillations of the atomic cloud (center of mass motion) will change the intensity of left/right propagating field components, thus shaking the membrane via changing the radiation pressure on it.

References

[1] K. Hammerer, K. Stannigel, C. Genes, P. Zoller, P. Treutlein, S. Camerer, D. Hunger, and T. W. Hänsch, preprint arXiv:1002.4646 (2010).

[2] D. Hunger, S. Camerer, T. W. Hänsch, D. König, J. P. Kotthaus, J. Reichel, and P. Treutlein, Phys. Rev. Lett. **104**, 143002 (2010).

[3] K. Hammerer, M. Wallquist, C. Genes, M. Ludwig, F. Marquardt, P. Treutlein, P. Zoller, J. Ye, and H. J. Kimble, Phys. Rev. Lett. **103**, 063005 (2009).