MAR16-2015-020064

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Hybrid atom-membrane optomechanics

PHILIPP TREUTLEIN, University of Basel, Department of Physics

We have realized a hybrid mechanical system in which ultracold atoms and a micromechanical membrane are coupled by radiation pressure forces. The atoms are trapped in an optical lattice, formed by retro-reflection of a laser beam from an optical cavity that contains the membrane as mechanical element. When we laser cool the atoms, we observe that the membrane is sympathetically cooled from ambient to millikelvin temperatures through its interaction with the atoms. Sympathetic cooling with ultracold atoms or ions has previously been used to cool other microscopic systems such as atoms of a different species or molecular ions up to the size of proteins. Here we use it to efficiently cool the fundamental vibrational mode of a macroscopic solid-state system, whose mass exceeds that of the atomic ensemble by ten orders of magnitude. Our hybrid system operates in a regime of large atom-membrane cooperativity. With technical improvements such as cryogenic pre-cooling of the membrane, it enables ground-state cooling and quantum control of mechanical oscillators in a regime where purely optomechanical techniques cannot reach the ground state. References: A. Jöckel, A. Faber, T. Kampschulte, M. Korppi, M. T. Rakher, and P. Treutlein, Sympathetic cooling of a membrane oscillator in a hybrid mechanical-atomic system, Nature Nanotechnology 10, 55 (2015). B. Vogell, T. Kampschulte, M. T. Rakher, A. Faber, P. Treutlein, K. Hammerer, and P. Zoller, Long distance coupling of a quantum mechanical oscillator to the internal states of an atomic ensemble, New J. Phys. 17, 043044 (2015). 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).