Q 1: Quantengase I [gemeinsam mit A]

Zeit: Montag 14:00–16:00 Raum: 1A

Hauptvortrag Q 1.1 Mo 14:00 1A

Cavity Optomechanics — •Tobias J. Kippenberg — Max Planck Institut fuer Quantenoptik

Achieving the quantum regime with mechanical objects offers fascinating possibilities for applied and fundamental Physics alike but has yet has been unattained so far. Remarkably, research groups working on mechanical systems ranging in size from nanometer-scale oscillators to centimeter-scale optical cavities to kilometer-scale gravity wave detectors are now all independently approaching a regime in which either the mechanical system or its interaction with the environment must be described quantum mechanically. These experiments will mark the beginning of the new research field of cavity Quantum Optomechanics. In this talk I will review our own efforts at the MPQ in this emerging research field; specifically, we have developed a novel laser cooling method (1,2) with which mechanical oscillators can be cooled - analogous to atomic laser cooling - and achieved unprecedented readout of mechanical motion. This technique provides a route towards ground state cooling of a mechanical oscillator. The mechanical oscillators in our work are provided by monolithic micro-cavities, which inherently combine mechanical and optical degree of freedom. I will describe the various efforts my group made towards achieving this interesting, yet highly challenging regime including the mechanical analog of Resolved Sideband Cooling.

References:

(1) A. Schließer et al. Phys. Rev. Lett. 97, 243905 (2006)

(2) I. Wilson-Rae et al. Phys. Rev. Lett. 99, 093901 (2007)

Gruppenbericht Q 1.2 Mo 14:30 1A

Bose-Einstein condensates coupled to solid state systems on an atom chip — •Philipp Treutlein[1,2], David Hunger[1,2], Stephan Camerer[1,2], Pascal Böhi[1,2], Max Riedel[1,2], Johannes Hoffrogge[1,2], Theodor W. Hänsch[1,2], Daniel König[2], Jörg P. Kotthaus[2], and Jakob Reichel[3] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München — [3]LKB, Ecole Normale Superieure, Paris

We present the status of two experiments which explore the interaction of atoms with micro- and nanofabricated solid state systems on a chip.

The first experiment aims at coupling a BEC to the mechanical oscillations of a nanoscale cantilever with a magnetic tip. Theoretical investigations of the magnetic coupling mechanism show that the atoms can be used as a sensitive probe for the cantilever dynamics. At low temperatures, the backaction of the atoms onto the cantilever is significant and the system represents a mechanical analog of cavity QED in the strong coupling regime [P. Treutlein et al., Phys. Rev. Lett. 99, 140403 (2007)].

In the second experiment, the solid state system is a miniaturized microwave guiding structure, which can be used to manipulate BECs. Through microwave dressing of hyperfine states, state-selective double-well potentials can be created. Such potentials have applications in quantum information processing, the study of Josephson effects, and could be used to entangle atoms via state-selective collisions [P. Treutlein et al., Phys. Rev. A 74, 022312 (2006)].

Gruppenbericht Q 1.3 Mo 15:00 1A

Dissipation Fermionizes a One-Dimensional Gas of Bosonic Molecules — •Dominik M. Bauer, Niels Syassen, Matthias Lettner, Thomas Volz, Daniel Dietze, Juan J. Garcia-Ripoll, Ignacio Cirac, Gerhard Rempe, and Stephan Dürr — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Many-body systems usually behave differently depending on whether the particles are bosons or fermions. However, bosons are forced to behave much like fermions if the system is one-dimensional (1D) and the interactions dominate the dynamics. This strongly correlated system is called a Tonks-Girardeau gas [1,2] and was observed with atoms in optical lattices [3,4]. All this work dealt with conservative interactions. Here we demonstrate a surprising generalisation, namely that inelastic collisions produce a dissipative analogue of the Tonks-Girardeau gas. We report on an experiment with molecules confined to 1D in an optical lattice. Inelastic collisions between the molecules create strong correlations that suppress the molecule loss rate by a factor of about 10. We dramatically increase this suppression by adding a lattice along the 1D direction. We develop theory which agrees with our experimental observations. Our work offers perspectives to create other, and possible new, strongly correlated states using dissipation.

[1] Tonks, L. *Phys. Rev.* **50**, 955-963 (1936).

[2] Girardeau, M. *J. Math. Phys.* **1**, 516-523 (1960).

[3] Paredes, B. *et al. Nature* **429**, 277-281 (2004).

[4] Kinoshita, T. *et al. Science* **305**, 1125-1128 (2004).

Gruppenbericht Q 1.4 Mo 15:30 1A

Strong dipolar effects in Chromium Bose-Einstein condensates (Gruppenbericht) — •Jonas Metz, Bernd Fröhlich, Tobias Koch, Thierry Lahaye, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

The experimental observation of strong dipolar effects in a Bose-Einstein condensate of Chromium are presented. Starting with dipolar interactions which perturb the usual contact interactions, we use a Feshbach resonance to reduce and finally switch off the contact interaction. We investigate the stability diagram of a purely dipolar gas for various trap shapes and find a universal behaviour in the large N case for all dipolar gases. We then induce a dipolar collapse and study the dynamics. Quantitative comparison with theoretical calculations by the Ueda group of Tokyo University are presented. The symmetry of the dipolar interaction is observed in the collapse products.