A 18: Ultracold atoms II (jointly with Q)

Zeit: Donnerstag 8:30–10:00 Raum: 2F

A 18.1 Do 8:30 2F

Towards laser cooling of negative ions — •Raoul Heyne, Jan Meier, Ulrich Warring, and Alban Kellerbauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

Currently available ion cooling techniques do not allow the cooling of negatively charged particles confined in an ion trap to a temperature lower than that of the (cryogenic) environment. The proposed laser cooling of negative osmium ions [1] holds the prospect of achieving temperatures well below 1 mK. Cooling antiprotons with this technique might open the door to forming antihydrogen at ultra-cold temperatures, thus allowing precision antimatter studies. We will outline the unique techniques and challenges involved in this cooling scheme and report intermediate results on Os^- production, manipulation, and spectroscopy.

[1] A. Kellerbauer and J. Walz, "A novel cooling scheme for antiprotons," New J. Phys. **8** (2006) 45.

A 18.2 Do 8:45 2F

Slicing a Bose-Einstein Condensate: Direct observation of number squeezing — •Christian Gross, Jerome Esteve, Andreas Weller, Stefano Giovanazzi, and Markus K. Oberthaler — Kirchhoff Institut für Physik, Universität Heidelberg

Todays interferometers are very often limited by the standard quantum limit. Pushing the performance beyond this limit demands the use of number squeezed states.

We report on the direct observation of number squeezed states in Bose-Einstein Condensates (BEC). These are produced by ramping up a one dimensional optical lattice adiabatically, slicing an initially almost pure condensate of ^{87}Rb atoms into seven pieces.

Our system can be described as an array of Josephson junctions. The effective interaction between the atoms increases with barrier height and their motion is more and more restricted to single wells since the tunneling coupling across the junctions decreases. In this regime the ground state of the Josephson junction array is characterized by a loss of phase coherence and sub shot noise atom number fluctuations across the junctions.

A 18.3 Do 9:00 2F

Observation of dark soliton oscillations in a harmonic trap — •Andreas Weller, Christian Gross, Jens Philipp Ronzheimer, Jerome Esteve, and Markus K. Oberthaler — Kirchhoff Institut für Physik, Universität Heidelberg

We experimentally create dark solitons in a Bose Einstein Condensate confined in a harmonic optical dipole trap by releasing atoms from a double well potential into a harmonic potential. The two clouds collide and form a dark soliton train. We observe the consequent dynamics (oscillations) with a novel imaging system. Furthermore we confirm that the oscillation frequency deviates from the harmonic trapping frequency and is close to the prediction of the one dimensional Gross Pitaevskii Equation (GPE): $\omega_{ds} = \omega_{trap}/\sqrt{2}$. The deviations are consistent with the results obtained by integration of the three dimensional GPE.

We will further discuss the status of the experiment creating intrinsically localized modes and bright solitons by starting with a single occupied well in an optical lattice.

A 18.4 Do 9:15 2F

Quantum State Engineering via Dissipation — •H.P. Büchler[1], S. Diehl[2], A. Kantian[2], B. Kraus[3], A. Micheli[2], and P. Zoller[2,3] — [1]Institut für Theoretische Physik, Universität Stuttgart — [2]Institut für Quantenoptik und Quanteninformation, Universität Innsbruck — [3]Insitut für Theoretische Physik, Universität Innsbruck

An open quantum system, whose time evolution is governed by a master equation, can be driven in steady state into a given pure quantum state by an appropriate design of the system-reservoir coupling. This points out a route towards preparing many body states and non-equilibrium quantum phases by quantum reservoir engineering. Here we discuss in detail the example of a driven dissipative Bose Einstein Condensate (BEC), where atoms in an optical lattice are coupled to a bath of Bogoliubov excitations via the atomic current representing local dissipation. In the absence of interactions the lattice gas is driven into a pure state with long range order. Weak interactions lead to a weakly mixed state, which in 3D can be understood as a depletion of the condensate, and in 1D and 2D exhibits properties reminiscent of a Luttinger liquid or a Kosterlitz-Thouless critical phase at finite temperature, with the role of the "finite temperature" played by the interactions.

A 18.5 Do 9:30 2F

Light propagation in ultracold atomic gases confined by optical lattices — •Stefan Rist and Giovanna Morigi — Departament de Fisica, Universitat Autonoma de Barcelona, 08193 Bellaterra, Spain

We develop a theory which describes photon propagation in a medium constituted by ultracold atoms confined by an optical lattice. We discuss in particular the input-output relations taking into account the finite size of the optical lattice and the atoms quantum motion and statistics. This work extends previous studies [1,2] by considering the atomic vibrations at the lattice sites, the finite tunneling matrix elements, and saturation effects of the atomic transitions. The coherence properties of the transmitted light are discussed as a function of the quantum state of the gas.

[1] Deutsch et al. Phys. Rev. A 52, 1394 (1995).
[2] Chong et al. Phys. Rev. B 75, 235124 (2007).

A 18.6 Do 9:45 2F

Superfluid properties of a Bose-Einstein condensate in an optical lattice confined in a cavity — •Aranya bhuti Bhattacherjee — Max Planck-Institute for Physics of Complex System, Noethnitzer Str.38, 01187 Dresden, Germany

In this work, we study the effect of a one dimensional optical lattice in a cavity field with quantum properties on the superfluid dynamics of a Bose-Einstein condensate(BEC). In the cavity the influence of atomic backaction and the external driving pump become important and modify the optical potential. Due to the coupling between the condensate wavefunction and the cavity modes, the cavity light field develops a band structure. This study reveals that the pump and the cavity now emerges as a new handle to control the coherence properties of the BEC, which offer the potential for improved interferometric technique, quantum information processing and efficient control of nonlinear excitations such as solitons. A wealth of new phenomena can be expected in the many-body physics of quantum gases with pump-cavity mediated interaction. Expressions for the tunneling parameter, the Bloch energy, the Bogoliubov spectrum and the effective mass in a quantum optical lattice are new results, derived here for the first time.