Q 65: Quantum gases: Bosons III

Time: Friday 14:00–16:00 Location: F 342

Group Report Q 65.1 Fri 14:00 F 342

Laser cooling to quantum degeneracy — •Simon Stellmer[1], Benjamin Pasquiou[1], Alex Bayerle[1,2], Slava Tzanova[1], Florian Vogl[2], Rudolf Grimm[1,2], and Florian Schreck[1] — [1]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria — [2]Institut für Experimentalphysik und Forschungszentrum für Quantenphysik, Innsbruck, Austria

So far, every cooling method capable of reaching BEC in dilute gases relied on evaporative cooling as the last and crucial cooling stage. Laser cooling to BEC has been strongly discussed middle of the 1990s, but the experimental capabilities of that time were insufficient to reach this goal. Choosing strontium as the atomic species allows for a new approach.

We prepare a sample of ^{84}Sr atoms in a large-volume *reservoir* dipole trap, constantly illuminated by cooling light on the narrow intercombination line that fixes the temperature to 800 nK. The density in the central region of the gas is increased by ramping up a *dimple* dipole trap. At the same time, we apply a *transparency* beam to this region of the sample. This beam is blue-detuned from a transition originating from the upper cooling state and selectively shifts this state out of resonance by 10^3 linewidths. Elastic collisions lead to a rapid accumulation of atoms in the dimple and ensure thermalization between the dimple and reservoir regions. A BEC of 10^5 atoms forms on a timescale of a few 10 ms. Laser cooling is the only cooling mechanism involved, while elastic collisions are indispensable for thermalization. This work holds prospects for the generation of a continuous atom laser.

Q 65.2 Fri 14:30 F 342

Universality of the Unitary-Limited Three-Body Loss Rate in Bosonic Systems — •Ulrich Eismann[1,2], Li-Chung Ha[1], Logan Clark[1], Eric Hazlett[1], Shih-Huang Tung[1], and Cheng Chin[1] — [1]The James Franck Institute and Department of Physics, University of Chicago, Chicago, IL 60637, USA — [2]Laboratoire Kastler Brossel, ENS, UPMC, CNRS UMR 8552, 24 rue Lhomond, 75231 Paris, France

In recent years, the tunability of quantum gases has become an standard experimental tool. It is established by exploiting magnetic Feshbach resonances in alkali atom collisions. In bosonic systems, however, strong interactions are accompanied by enhanced three-body loss, which therefore is an important practical limitation for tuning. However, apart from being a nuisance, three-body loss itself represents an important observable, and can be used to probe nonclassical correlations and few-body physics like the Efimov effect [1].

We present measurements of the temperature-dependent three-body loss rate in ultracold Bose gases at unitarity, where the two-body scattering amplitude becomes resonant. Experimentally, we exploit the *d*-wave Feshbach resonance near 48 G in the lowest hyperfine ground state of cesium-133. We confirm former measurements performed in the lithium-7 system [2] on a more than ten times higher temperature scale, providing evidence of universality of the unitary three-body loss rate. Given our excellent signal-to noise ratio, we discuss the experimental observability of Efimov-like oscillations in the loss spectrum.

[1] V. Efimov, Phys. Lett. B **33**, 563 (1970).
[2] U. Eismann, Ph.D. thesis, Université P. et M. Curie (2012).

Q 65.3 Fri 14:45 F 342

Density correlation of a mixture of ultracold atoms in an optical lattice — •Vladislav Gavryusev[1,2,3], Stefano Conclave[1,2], Giacomo Lamporesi[1,2], Devang Naik[1,2], Francesco Minardi[1,2], and Massimo Inguscio[1,2] — [1]LENS-European Laboratory for Non-Linear Spectroscopy and Dipartimento di Fisica, Universitá di Firenze, via N. Carrara 1, IT-50019 Sesto Fiorentino-Firenze, Italy — [2]CNR-INO, via G. Sansone 1, IT-50019 Sesto Fiorentino-Firenze, Italy — [3]Physikalisches Institut, Universitatät Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany

At LENS we have an experimental apparatus that can produce a double Bose-Einstein condensate of ^{87}Rb and ^{41}K atoms and trap it in a 3D optical lattice. The atomic sample is well described by the double species Bose-Hubbard model and its parameters can be experimentally controlled with great precision by varying the power of the trapping laser and by applying magnetic fields. We are interested in the arrangement of the atoms in the lattice and for this we require diagnostic methods that can access the relevant observables. We make use of the Hanbury Brown and Twiss effect, which, if there is a regular ordering of the atoms in the lattice, leads to the presence of a correlation in the fluctuations of the atomic density, caused by the quantum statistics of bosonic particles. Different orderings lead to different correlation patterns, allowing to discriminate ”ferromagnetic” and ”antiferromagnetic” phases. We validated our technique by studying the single species case and now we are making progress on applying this method to the double species case.

Q 65.4 Fri 15:00 F 342

Correlations of photonic BEC in a micro resonator — •Tobias Rexin[1], Carsten Henkel[2], and Axel Pelster[3] — [1]Zentrum für Optische Quantentechnologien and Institut für Laserphysik,Universität Hamburg, 22761 Hamburg, Germany — [2]Institut für Physik und Astronomie, Universität Potsdam, 14469 Germany — [3]Fachbereich Physik, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Light confined in a microcavity [1] is described by Maxwell's equations with appropriate boundary conditions. A careful analysis of the corresponding boundary value problem in suitable coordinates provides a systematic approach to determine the underlying mode functions for the cavity photon field. In paraxial approximation this three-dimensional microcavity problem can be reduced to an effective two-dimensional trapped massive Bose gas which supports the heuristic derivation of Ref. [2]. The obtained quantized photon field with its mode structure can be used to determine various thermodynamic and statistical quantities such as critical particle number and correlation functions. In particular we present the correlation for the cavity photons at finite temperature.

[1] J. Klaers, F. Vewinger, and M. Weitz, Nature Physics 6, 512 (2010).
[2] J. Klaers, J. Schmitt, F. Vewinger, and M. Weitz, Nature 468, 545 (2010).

Q 65.5 Fri 15:15 F 342

Defect-induced supersolidy with soft-core Bosons — •Fabio Cinti[1], Tommaso Macri[1], Wolfgang Lechner[2], Guido Pupillo[3], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]IQOQI and Institute for Theoretical Physics, University of Innsbruck, 6020 Innsbruck, Austria — [3]ISIS (UMR 7006) and IPCMS (UMR 7504), Universite' de Strasbourg and CNRS, Strasbourg, France

More than 40 years after its conjecture by Andreev, Lifshitz and Chester the possible existence of continuous-space supersolids due to delocalized zero-point defects still remains under active debate. Here we show that soft-core Bosons confined to two-dimensions give rise to the emergence of this elusive state. We present a detailed study of the zero-temperature phase-diagram in the strongly coupled regime and identify conditions for defect-induced supersolidity, i.e. for the formation of an incommensurate crystal in the ground state of the system. In addition to displaying supersolidity the phase diagram shows a rich structure and contains other interesting phases, such as commensurate supersolid.

Q 65.6 Fri 15:30 F 342

Thermodynamics of ultracold Bose gases at a dimensional crossover — •Ralf Labouvie, Andreas Vogler, Vera Guarrera, and Herwig Ott — Research Center OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern

We have studied the thermodynamics of ultracold Bose gases in the crossover from a three-dimensional to a one-dimensional regime.

In our experiment, we use a focussed electron-beam to probe in situ atomic density distributions with high temporal and spatial resolution. Starting with a Bose-Einstein-Condensate in a single beam optical dipole trap we can create one-dimensional systems by loading the atoms in a two-dimensional blue-detuned optical lattice. With increasing strength of the lattices we go from a three-dimensional into a one-dimensional system. Furthermore we tune the interaction strengths of the one-dimensional quantum-gases from weak (quasi-condensate) to strong (Tonks-Girardeau). By measuring the density profiles and applying an inverse Abel-Transformation we extract the equation of states of these systems and characterize the crossover from the three-dimensional to the one-dimensional regime.

Q 65.7 Fri 15:45 F 342

Coherence properties of Bose-Einstein condensates in an optical storage ring — •Johannes Küber[1], Thomas Lauber[1], Felix Schmaltz[1], Jordi Mompart[2], and Gerhard Birkl[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Schlossgartenstraße 7, 64289 Darmstadt — [2]Departament de Física, Universitat Autònoma de Barcelona, E-08193 Bellaterra, Spain

We present experiments with Bose-Einstein condensates (BEC) performed in an optical storage ring.

The optical storage ring is a combination of a blue detuned double-ring trapping potential which is formed by conical refraction and a red detuned lightsheet potential which supports the atoms against gravity. The ring shaped trapping potential is created by a birefringent crystal which is appropriately polished and aligned along one of the optical axes. The resulting image in the focal plane resembles two bright rings with a dark ring in between. The trapping potential is loaded with an all-optical BEC created with an multi-mode fiber laser at 1070nm.

The experiments performed in the optical trapping potential show that a coherent transport in this novel structure is possible. The measured coherence length of $(2.53 \pm 0.75)\mu m$ of a wave packet traveling in the potential resembles the coherence length of a BEC at rest after condensation. Additionally we show different loading techniques of the ring and ongoing analysis of interferometric measurements of BEC in our ring shaped potential.