Q 45: Ultra Cold Atoms, Ions and BEC III (with A)

Time: Thursday 10:30–12:30 Location: F 303

Q 45.1 Th 10:30 F 303

All-Optical Cooling and Diagnostics for Relativistic Ion Beams — •Michael Bussmann[1], Ulrich Schramm[1], Danyal F.A. Winters[2,3], Thomas Walther[4], Gerhard Birkl[4], Christina Dimopoulou[3], Fritz Nolden[3], Markus Steck[3], Bernhard Franzke[3], Christian Novotny[3,5], Christopher Geppert[3,5], Wilfried Nörtershäuser[3,5], Christophor Kozhuharov[3], Thomas Kühl[3], and Thomas Stöhlker[2,3] — [1]Forschungszentrum Dresden-Rossendorf e.V., D-01328 Dresden — [2]Ruprecht-Karls-Universität Heidelberg, D-69120 Heidelberg — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, D-64291 Darmstadt — [4]Technische Universität Darmstadt, D-64289 Darmstadt — [5]Johannes-Gutenberg-Universität Mainz, D-55099 Mainz

Laser cooling of ion beams at relativistic energies at the Experimental Storage Ring (ESR) at GSI has shown that in order to address the complete phase space of an initially hot ion beam, laser systems have to deliver light at a wide range of frequencies. If all ions are cooled by the laser force, the beam momentum spread can be reduced to a level that cannot be resolved by standard accelerator diagnostics. In our talk we introduce new laser systems and optical diagnostics that are currently set up for an upcoming laser cooling experiment at ESR. We discuss the impact of these new developments on the detection of beam ordering referring to laser cooling experiments previously performed at the ESR.

Q 45.2 Th 10:45 F 303

Measurements of the Interaction between Ultracold Atoms and Carbon Nanostructures — •Philipp Schneeweiss[1], Michael Gierling[1], Gabriela Visanescu[1], Johannes Märkle[1], Benjamin Jetter[1], Thomas Judd[1], Michael Häffner[1], Dieter Kern[1], Carsten Weiss[2], Reinhold Walser[3], Andreas Günther[1], and József Fortágh[1] — [1]Center for Collective Quantum Phenomena and their Applications, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen — [2]Institut für Quantenphysik, Universität Ulm, D-89069 Ulm — [3]Institut für Angewandte Physik, TU Darmstadt, Hochschulstraße 4a, D-64289 Darmstadt

We have developed an ultracold atom experiment for studying interactions between Rubidium atoms and carbon nanotubes (CNTs). In a first series of measurements, ultracold atom clouds have been used as a scanning probe for measuring the topography of CNT structures on a chip surface. A magnetic conveyor belt allows the three-dimensional nano-positioning of atomic ensembles above the chip. The method can successfully resolve extended arrays and lines of nanotubes, as well as individual, freestanding CNTs.

In a second experiment, the loss and heating rates of atom clouds spatially overlapping with a single, freestanding CNT have been measured. Using the data, we quantify the total scattering cross-section and compare it to the geometrical cross-section between the atoms and the single CNT. We find first evidence for the influence of Casimir-Polder effects in the interaction and discuss its contributions to the scattering cross-section.

Q 45.3 Th 11:00 F 303

Controlling spin dynamics in a one-dimensional quantum gas — •Philipp Wicke, Shannon Whitlock, and Klaasjan van Druten — Van der Waals-Zeeman Institute, University of Amsterdam, The Netherlands

Reducing the dimensionality of a system has dramatic consequences and leads to remarkable new physics. In this regard, quantum gases offer unique opportunities to address important open questions in quantum many-body physics, by allowing full control over all relevant parameters. We create coherent superpositions of both spin and motional degrees of freedom and probe spin dynamics of a one-dimensional (1D) Bose gas of ^{87}Rb on an atom chip. We observe interaction driven focusing of one spin component by mean field interaction with another component, directly related to the effective 1D interaction strength. We demonstrate experimental control over the 1D interaction strengths through state-selective radio-frequency dressing. The focusing behaviour is altered by tuning the transverse trapping potential in a state-dependent way. This enables, for instance, access to the point of spin-independent interactions where exact quantum many-body solutions are available.

Q 45.4 Th 11:15 F 303

Collisions of single ions with ultracold neutral atoms — •Stefan Schmid[1,2], Arne Härter[1,2], and Johannes Hecker Denschlag[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria — [2]Institut für Quantenmaterie, Universität Ulm, Albert-Einstein-Allee 45, 89081 Ulm, Germany

We have set up an experiment in which a single trapped Ba^+ ion is immersed into a sea of ultracold neutral Rb atoms.

In the Paul trap we can store single ions as well as strings of several ions cooled to the Doppler limit. We produce our BEC in a QUIC trap and transport it over 30 cm into a linear Paul trap using a moving 1D optical lattice. Subsequently the atoms are loaded into a crossed dipole trap, which is overlapped with the position of the ion.

First experimental results on the collisions of the ion with the ultracold sample are shown.

Q 45.5 Th 11:30 F 303

Nonlinear atom interferometer beats classical precision limit — •Eike Nicklas, Christian Gross, Tilman Zibold, Jérôme Estève, and Markus K Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg, Germany

The phase detection precision of classical linear atom interferometers is limited by the standard quantum limit. We report on the realization of a nonlinear atom interferometer based on two hyperfine states of Bose-Einstein condensed Rubidium. The nonlinearity is provided by elastic s-wave collisions and we implemented precision control of the scattering length by employing a narrow Feshbach resonance. In a prototypal measurement with a macroscopic number of atoms we find a precision enhancement of 15% over the standard quantum limit. Within the interferometer a large entangled state with 170 entangled atoms is detected.

Q 45.6 Th 11:45 F 303

From single to many particle Rabi oscillations — •Tilman Zibold, Eike Nicklas, Christian Gross, Helmut Strobel, Ion Stroescu, Wolfgang Müssel, and Markus K. Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg, Germany

We experimentally investigate the Josephson dynamics between two weakly coupled spin states in a Bose-Einstein condensate of Rubidium. The relevant parameters of this system are the interaction energy and the tunneling rate. Our system allows for the tuning of the interaction energy by an inter species Feshbach resonance whereas the tunneling rate is controlled by the two photon coupling between the modes. The Josephson dynamics can be divided in three different regimes characterized by the emergence of different dynamics. The adjustability of the system allows us to enter all these three regimes. By measuring atom number imbalance and the corresponding phase we are able to map out phase plane trajectories of all predicted dynamics. The occurrence of self trapped states is further investigated to identify the corresponding bifurcation in the phase plane portrait. The analysis of the small amplitude oscillations with mean phase 0 and pi respectively allows us a precise determination of the interaction energy between the two modes and therefore a characterization of the elastic part of the Feshbach resonance.

Q 45.7 Th 12:00 F 303

Preparation of a degenerate mesoscopic sample of fermions — •Friedhelm Serwane[1,2], Timo Ottenstein[1,2], Thomas Lompe[1,2], Gerhardt Zürn[1,2], Martin Ries[1,2], Philipp Simon[1,2], and Selim Jochim[1,2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Physikalisches Institut, Universität Heidelberg

Systems consisting of only few degenerate interacting fermions have prominent examples in nature: e.g. nuclei in the atomic core. Our goal is the preparation of such a system with tunable properties in the laboratory using ultracold fermionic ^{6}Li atoms. Here, the interaction strength can be tuned over many orders of magnitude by means of a Feshbach resonance.

With the ability to control the number of fermions in the trap, studies of the system's properties in dependence of the atom number n will become possible. One intriguing example is the appearance of many-body effects such as superfluidity. In the extreme limit, the sample consists of only two atoms in different spin states which potentially can be used as a high-fidelity qubit.

To control n precisely, we transfer atoms from a large optical dipole trap into a micron-sized dipole trap with well separated energy levels. By applying a magnetic field gradient, we are able to spill atoms in a controlled way ending up with a highly degenerate Fermi gas. So far we can control the atom number down to 120 atoms, limited by the imaging technique. Also we were able to count single atoms in a MOT with fluorescence imaging. In the next step we will combine these techniques to study smaller samples of highly degenerate fermions.

Q 45.8 Th 12:15 F 303

Study of matter-wave speckle patterns — •Nicolas Cherroret[1] and Sergey Skipetrov[2] — [1]Quantum optics and statistics group, Institute of Physics, Albert Ludwigs University of Freiburg, Germany — [2]Laboratoire de Physique et Modélisation des Milieux Condensés, Grenoble, France

The behavior of Bose-Einstein Condensates (BECs) in disordered potentials attracts growing interest of physicists during the last few years. More specifically, the properties of a BEC released from a trap in a random potential has been studied. From the experimental viewpoint, BEC systems are very controllable and versatile, and direct measurements of the atomic spatial density n(r) can be performed. During the last two years, considerable efforts were made to study the ensemble average of n(r) in 1D, 2D, and 3D systems, with special interest in the phenomenon of Anderson localization. In the same time, very few results concern the statistics of n. However, it is well known that a wave propagating in a disordered medium generates a complicated intensity pattern ("speckle") due to multiple scattering from inhomogeneities. Since a weakly interacting BEC can be regarded as a coherent matter wave, an analogous phenomenon should also show up in the case of BECs. We analyze these "matter-wave speckle patterns" theoretically and show that they exhibit long-range density correlations, strongly enhanced at long times, which can even take negative values for sufficiently distant points.

Reference: N. Cherroret and S.E. Skipetrov, Phys. Rev. Lett. 101, 190406 (2008)