Q 52: Cold atoms VI - traps (joint session A/Q)

Time: Thursday 10:30–12:15 Location: K 0.011

Q 52.1 Thu 10:30 K 0.011

Dipole trapping in the absence of gravity — •Christian Vogt[1], Marian Woltmann[1], Sven Herrmann[1], Claus Lämmerzahl[1], and The PRIMUS-Team[1,2] — [1]University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen — [2]Institut für Quantenoptik, LU Hannover

Cold atoms have proven to be a useful toolbox with wide applications in testing the fundamentals of physics, e.g the weak equivalence principle which provides the cornerstone of Einstein's general relativity theory [1]. In the recent years great effort has been made to take advantage of these techniques in weightlessness. For example the first BEC in space was created and effective temperatures down to the pK regime were demonstrated in the drop tower in Bremen [2]. So far all of these result from atoms held in magnetic traps on atom chips. This talk will be about the first realization of a dipole trap in weightlessness. Proven its worth on ground , dipole traps have never before been operated in microgravity, although they can produce high number BECs and have unique advantages like the ability to apply feshbach resonances. Our experiment, the PRIMUS project, uses the drop tower in Bremen witch offers up to 4.7s of microgravity time in drop mode. The talk will focus on the dimension of evaporation and the reduction of evaporation time. The PRIMUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) under grant number DLR 50 WM 1642. [1] D. Schlippert et al., Phys. Rev. Lett. 112, 203002 (2014) [2] Jan Rudolph,(PhD Thesis), Leibniz University Hannover, 2016.

Q 52.2 Thu 10:45 K 0.011

A high repetition deterministic ion source — •Cihan Sahin, Philipp Geppert, Adreas Müllers, and Herwig Ott — Technische Universität Kaiserslautern

An ion source with minimal energy spread and deterministic operability has many possible applications in basic research and technical applications including surface spectroscopy, ion microscopy, ion implantation or milling. Key requirements for these applications include among others a high degree of control of ion trajectories and high rates.

We developed an ion source capable of delivering ions on demand with high fidelity. The basis of our ion source is a magneto-optical trap (MOT) of ^{87}Rb atoms. The atoms are photoionized by a three photon process within a small volume inside the MOT. A symmetric detector setup for electrons and ions allows to detect the ionization fragments.

We can classify the operation of the source in three modes. In the single ion operation mode the electron is used to switch for a short time a gating electrode on and so let the corresponding ion pass. With an additional external trigger deterministic operation mode is enabled and single ions are provided on demand with high fidelity around a rate of $10\,000\,\mathrm{s}^{-1}$. The source can also be used in the continuous operation mode delivering ions with a rate of $1 \times 10^6\,\mathrm{s}^{-1}$.

Q 52.3 Thu 11:00 K 0.011

Time-dependent custom tailored optical potentials — •Lukas Palm, Marvin Holten, Philipp M. Preiss, and Selim Jochim — Physikalisches Institut der Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Engineering quantum states of ultracold atoms requires precise control over the confining potentials. Spatial light modulators displaying computer generated holograms are readily employed to spatially shape such optical potentials in a wide variety of geometries. However, their capabilities in the time domain are severely restricted by the refresh rate of the device.

We utilize multiple optical modes with a relative detuning to realize time-dependent potentials where RF control of the optical frequencies allows a wide range of modulation rates. This allows the creation of rapidly rotating traps where high angular momenta and strongly correlated states are accessible. Therewith we want to realize quantum Hall physics in a few fermion system.

Q 52.4 Thu 11:15 K 0.011

Thermodynamics of a non-equilibrium single-atom system — •Daniel Mayer[1], Daniel Adam[1], Quentin Bouton[1], Steve Haupt[1], Tobias Lausch[1], Felix Schmidt[1], and Artur Widera[1,2] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Gottlieb-Daimler-Strasse 47, 67663 Kaiserslautern, Germany

We report on the experimental investigation of phase space dynamics of individual atoms, quenched out of equilibrium by a Raman cooling pulse. We numerically model our findings by using an effective two-temperature approach, yielding excellent agreement with the experimental data. For application of multiple pulses, we observe the approach of a thermal state with a new temperature.

Experimentally, we prepare a few atom sample of laser cooled Cs atoms in a crossed, optical dipole trap. We apply a pulse of degenerate Raman sideband cooling, thereby quenching the phase space distribution of the sample. The dynamics emerging after the quench is observed by two distinct methods: we extract information about the radial momentum distribution by a release-recapture experiment while in axial direction we use fluorescence imaging in a 1D optical lattice to observe the atomic position distribution.

Q 52.5 Thu 11:30 K 0.011

Precision measurement of the dynamical polarizability of dysprosium at 1064nm — Cornelis Ravensbergen[1,2], •Vincent Corre[1,2], Elisa Soave[2], Marian Kreyer[1,2], Slava Tzanova[1,2], Emil Kirilov[2], and Rudolf Grimm[1,2] — [1]Institut für Quanten Optik und Quanten Information, Innsbruck — [2]Institut für Experimental Physik, Universität Innsbruck

The field of ultracold dipolar gases has grown vastly in the last years, motivated by the new phases made accessible by the long-range anisotropic dipole-dipole interaction. Among dipolar systems, atomic gases of lanthanides - erbium and dysprosium - have been cooled down to the degenerate regime and have demonstrated striking dipolar effects. But while the geometry of the trapping potential is known to have a critical influence on the behavior of these gases, questions remain about the value of the dynamical polarizability of dysprosium, as a large discrepancy still exists between theoretical calculations and experimental measurements. We report on a new measurement of the dynamical polarizability of dysprosium at 1064 nm with unprecedented precision. We take advantage of our dual-species experimental set-up and use potassium as a reference species. By calibrating the polarizability of dysprosium on the one of potassium, which is well known, we free ourselves from the main sources of systematic error that are the trapping laser waist and aberrations, and anharmonicity effects. We check that other possible error sources have negligible effect. Eventually we obtain values for the scalar and tensor parts of the polarizability with a relative error of 2%, that are close to the theoretical predictions.

Q 52.6 Thu 11:45 K 0.011

Tuning collective dipole-dipole interactions via cavities — •Helge Dobbertin and Stefan Scheel — Institut für Physik, Universität Rostock, Albert-Einstein-Straße 23, 18059 Rostock, Germany

When resonant atoms are confined inside a volume smaller than the transition wavelength λ cubed, they couple via strong dipole-dipole interactions and show a collective response to near-resonant light. Recent studies [1] found that the resulting line shifts of cold atomic gases substantially differ from the textbook Lorentz-Lorenz effect. At finite temperature [2] an additional density dependent shift occurs due to collisions.

Here, we discuss possibilities to tune the dipole-dipole interactions by means of macroscopic cavity geometries. This may offer a new handle to separate collisional and dipole-dipole induced shifts and to study the microscopic basis of local-field corrections in cold and thermal atomic ensembles [3].

[1] J. Pellegrino et al., Phys. Rev. Lett. **113**, 133602 (2014).
[2] J. Keaveney et al., Phys. Rev. Lett. **108**, 173601 (2012).
[3] J. Javanainen et al., Phys. Rev. A **96**, 033835 (2017).

Q 52.7 Thu 12:00 K 0.011

Dipolar quantum droplets and striped states — •Fabian Böttcher, Matthias Wenzel, Jan-Niklas Schmidt, Michael Eisenmann, Tim Langen, Igor Ferrier-Barbut, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

The dipolar interaction allows for self-organized structure formation similar to the Rosensweig instability in classical ferrofluids. In our experiments with quantum gases of Dysprosium atoms, we observe a phase-transition between a gas and a liquid, characterized by the formation of self-bound droplets. In contrast to theoretical mean field predictions the superfluid droplets did not collapse. We confirmed experimentally that this unexpected stability is due to beyond mean field quantum corrections of the Lee-Huang-Yang type. These droplets are 100 million times less dense than liquid helium droplets and open new perspectives as a truly isolated quantum system.

Under strong confinement in one dimension, we observe the formation of an array of stripes. We also study striped ground states theoretically and outline prospects to reach a phase coherent supersolid ground state.

In a further ongoing experiment we rotate the droplets by a spinning magnetic field and observe that they can be rotated faster than the transverse trapping frequency due to a surface tension counteracting the centrifugal force. We also observe the excitation of a scissors mode of the droplets.