A 36: Ultra-cold atoms, ions and BEC IV (with Q)

Time: Thursday 14:30–16:30 Location: f303

A 36.1 Thu 14:30 f303

Spectroscopy of Topological Defects in Coulomb Crystals — •Philip Kiefer[1], Jonathan Brox[1], Miriam Bujak[1], Isabelle Schmager[1], Haggai Landa[2], and Tobias Schaetz[1] — [1]Atom-, Molekül- und optische Physik, Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]LPTMS, Université Paris Sud, Orsay, France

We study structural defects (kinks) experimentally, which we form during two related phase-transitions in Coulomb crystals. A cloud of ^{24}Mg-Ions is freezed into a crystalline structure, consisting of several tens of ions in a linear radiofrequency trap [1]. We observe the formation of topological defects with a structural phase transition from a linear chain to a 2D-zig-zag configuration. Numerical simulations predict a strong anharmonicity of the kink's internal mode of vibration [2].

We observe the defects' experimental occurrence, lifetime and annihilation due to controlled motional excitation of the localized mode. We reveal evidence for the (gapped) localized mode and present first data of spectroscopy results. Furthermore, the formation of kink configurations and the transformation of kinks between different structures in dependence on the trapping parameters are investigated.

[1] M. Mielenz et al., Phys. Rev. Lett. **110**, 133004 (2013)
[2] H. Landa et al., New J. Phys. **15**, 093003 (2013)

A 36.2 Thu 14:45 f303

Quantum phases of ultracold dipolar bosons in a highly anisotropic trap — •Florian Cartarius[1,2], Anna Minguzzi[2], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Laboratoire de Physique et Modelisation des Milieux Condenses, Universite-Grenoble Alpes and CNRS, 25 avenue des martyrs, F-38042 Grenoble, France

We study two dimensional dipolar bosons in an optical lattice, tightly confined to a string by a highly anisotropic harmonic potential. The bosons are polarized perpendicular to the plane by an external field, so that they interact via the repulsive part of the dipolar potential. For very strong harmonic confinements, the dipoles are in the lowest energy state of the transverse harmonic oscillator. This breaks down when the transverse confinement frequency is decreased below a critical value. In this regime, we show that the system can be mapped onto several coupled extended Bose-Hubbard Hamiltonians, where the coefficients can be determined by means of a low energy theory [1]. We determine the ground state of this Bose-Hubbard Hamiltonian as a function of the trap aspect ratio and of the strength of the dipolar potential, and analyse the conditions under which Haldane-like phases and pair-superfluidity can occur.

[1] F. Cartarius, G. Morigi, and A. Minguzzi, Phys. Rev. A 90, 053601 (2014)

A 36.3 Thu 15:00 f303

On the heteronuclear Efimov effect with van der Waals interactions — •Juris Ulmanis[1], Stephan Häfner[1], Rico Pires[1], Yujun Wang[2], Chris H. Greene[3], Eva D. Kuhnle[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Department of Physics, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506, USA — [3]Department of Physics, Purdue University, West Lafayette, Indiana, 47907-2036, USA

Ultracold Bose-Fermi mixture of ^{133}Cs and ^{6}Li atoms constitutes a prototypical system with mass imbalance that allows thorough exploration of the heteronuclear Efimov effect – the formation of an infinite geometrical series of bound three-body states for resonant two-body interactions. Here we present our measurements and analysis of three-body recombination spectra of Li+Cs+Cs close to two broad Li-Cs Feshbach resonances. Two series of consecutive Efimov resonances, each characterized by different sign and magnitude of Cs-Cs s-wave scattering length, are observed, showing deviations from the geometric scaling law. For positive Cs-Cs scattering lengths the three-body resonance that is associated to the Efimov ground state is missing. This is in agreement with the spinless van der Waals theory that predicts the transformation of the Efimov ground state into the Li + Cs_2 scattering channel, and modification of the scaling factors via short-range effects. These findings provide a comprehensive picture of universal and non-universal features in the heteronuclear Efimov scenario.

A 36.4 Thu 15:15 f303

Sympathetic cooling of ions inside a radio frequency trap — •Bastian Höltkemeier[1], Pascal Weckesser[1], Henry Lopez[1], Andre de Olivera[1,2], Ji Luo[1], Eric Endres[3], Roland Wester[3], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Heidelberg, INF 226, 69120 Heidelberg — [2]Departamento de Física, Universidade do Estado de Santa Catarina-Joinville, SC, Brazil — [3]Institut f. Ionenphysik und angewandte Physik, Universität Innsbruck, Technikerstraße 25/3, 6020 Innsbruck

Sympathetic cooling has become a powerful and universal method for preparing ultracold ions confined in radio frequency traps. We theoretically investigate the possibility of using laser-cooled atoms as a buffer gas. Recent theories indicate that cooling of ions in radio frequency traps is limited to atom-to-ion mass ratios below unity. Using a localized buffer gas cloud and/or a higher order radio frequency trap this limitation can be overcome. A description of our model and the corresponding cooling limit for experimental applications will be presented. We show how the ion's final temperature can be tuned by adjusting the appropriate experimental parameters, such as the rf-voltage or the atom cloud size (Forced Sympathetic Cooling).

A 36.5 Thu 15:30 f303

Single particle dynamics in an ultracold environment: From superfluidity to finite size reheating — •Paula Ostmann and Walter Strunz — TU Dresden, Inst. f. Theor. Physik, Zellescher Weg 17, 01062 Dresden

We investigate the quantum dynamics of a single ion which is immersed into a Bose-Einstein condensate. The ultracold environment acts as a refrigerator, and thus, the influence on the motion of the ion is dissipative. For a theoretical description, simple phenomenological master equation approaches are widely used to describe the ensuing damped quantum dynamics. Instead of calculating the particle dynamics itself, our focus lies on a more detailed description of the environment and the particle-environment interaction. We aim to describe the effective dynamics of the damped particle dynamics using the full bath correlation function instead of a simple damping rate. In this way we gain a more thorough theoretical understanding of properties of quantum matter, such as superfluidity, when acting as an environment.

We find that we can divide the dynamical effect of the BEC on the ion into two parts: The initial energy loss and the return of energy to the ion dynamics. By considering just the initial decay we effectively study an ion coupled to an infinitely large environment and are able to identify a Landau Criterion for a quantum particle in a harmonic trap. Secondly we see that the finite size of the condensate causes the return of the energy, which results in a periodically reheating of the ion, which could be used as an additional cooling mechanism as well.

A 36.6 Thu 15:45 f303

Radio-frequency dressed detection of atomic clock states — •Sindhu Jammi, Tadas Pyragius, Mark Bason, and Thomas Fernholz — School of Physics and Astronomy, University of Nottingham

We introduce a new method to dispersively measure population and population difference of alkali atoms prepared in their two clock states (m=0). Linear birefringence of the atomic medium allows atom number detection via polarisation homodyning, i.e. common path interferometry. In order to achieve low technical noise levels, we perform sideband detection after adiabatically transforming the atomic states via radio-frequency dressing. The balanced homodyne signal then oscillates at twice the dressing frequency, independent of field fluctuations, thus allowing for robust, phase-locked detection that circumvents low-frequency noise. Using probe pulses of two optical frequencies consecutively, we can detect both atomic states separately and obtain population difference as well as total atom number in a single experimental cycle. Simultaneously pulsed detection can be used for direct subtraction of the homodyne signals, which we expect to enable quantum noise limited measurements and preparation of spin squeezed states. The method can thus be used in atomic clocks and atom interferometric measurements.

A 36.7 Thu 16:00 f303

Development of a deterministic ion source based on ultracold atoms — •Cihan Sahin, Andreas Müllers, Jens Benary, and Herwig Ott — Technische Universität Kaiserslautern

A deterministic ion source using ultracold atoms can provide ions with low energy spread at high repetition rates. These properties are beneficial for experiments on ion interferometry or semiconductor doping.

In our experiment, a magneto optical trap (MOT) storing ^{87}Rb atoms acts as an ion source. The atoms are photoionized from the $5P_{3/2}$ state with a 405 nm laser. Both electrons and ions are detected with channel electron multipliers (CEM). The electrons serve as triggers for the ions, which would enable us to predict and control the ions.

As a next step, the ions will be detected with a position sensitive multi channel plate (MCP) with a delay line detector (DLD) to characterize their energy spread and position resolution.

We discuss the status of the experiment and present results obtained so far.

A 36.8 Thu 16:15 f303

Dimensional phase transition from 1D behavior to a 3D Bose-Einstein condensate — Denis Morath, •Dominik Strassel, Axel Pelster, and Sebastian Eggert — Department of Physics and Research Center Optimas, University Kaiserslautern, 67663 Kaiserslautern, Germany

The emergence of new properties from low-dimensional building blocks is a universal theme in different areas in physics. The investigation of transitions between isolated and coupled low-dimensional systems promises to reveal new phenomena and exotic phases. Interacting 1D bosons, which are coupled in a two-dimensional array, are maybe the most fundamental example of a system which illustrates the concept of a dimensional phase transition. However, recent experiments using ultracold gases have shown a surprising discrepancy between theory and experiment [1] and it is far from obvious if the power laws from the underlying 1D theory can predict the transition temperature and order parameter correctly for all interaction strengths. Using a combination of large-scale Quantum Monte-Carlo simulations and chain mean-field calculations, we show that the behavior of the ordering temperature as a function of inter-chain coupling strength does not follow a universal powerlaw, but also depends strongly on the filling.

[1] A. Vogler, R. Labouvie, G. Barontini, S. Eggert, V. Guarrera, and H. Ott, Phys. Rev. Lett. 113, 215301 (2014)