Q 51: Ultra-cold atoms, ions and BEC III

Time: Thursday 14:00–16:00 Location: V47.02

Q 51.1 Thu 14:00 V47.02

A transportable setup for investigation of multiple charge transfer — •Simone Götz[1], Bastian Höltkemeier[1], Matthias Weidemüller[1], and Brett DePaola[2] — [1]Philosophenweg 12, 69126 Heidelberg — [2]Kansas State University, Kansas, USA

We report on a transportable compact setup combining a dark SPOT (spontaneous optical trap) for Rubidium atoms with a recoil ion momentum spectrometer [1]. The target is loaded with high flux from a 2 dimensional magneto-optical trap, achieving densities of up to 10^{11} atoms/cm^{-3}. The spectrometer is characterized measuring the ion recoil energy in photoionization of the trapped atoms [2,3].

In collaboration with the GSI in Darmstadt this setup will be used to investigate correlation effects in multiple charge transfer between the rubidium atoms and highly charged ions. An outlook will be given.

[1] J. Ullrich *et al.*, J Phys. B **30**, 2971 (1997)
[2] S. Wolf *et al.*, PRA **56**, R4385 (1997)
[3] S. Wolf *et al.*, PRA **62**, 043408 (2000)

Q 51.2 Thu 14:15 V47.02

Quantum magnetism of mass-imbalanced fermionic mixtures — •Andrii Sotnikov[1], Daniel Cocks[1], Michiel Snoek[2], and Walter Hofstetter[1] — [1]Goethe University, Frankfurt am Main, Germany — [2]Universiteit van Amsterdam, The Netherlands

We study magnetic phases of two-component mixtures of repulsive fermions in optical lattices in the presence of mass imbalance. The analysis is based on dynamical mean-field theory (DMFT) and its real-space generalization at finite temperature. The dependencies of the transition temperature to the ordered state on the interaction strength and the imbalance parameter are studied both in two and three spatial dimensions. For a harmonic trap, we compare our results obtained by real-space DMFT to results from a local-density approximation.

Our approach allows us to calculate the entropy at different parameters of the system and discuss the cases in which mass-imbalanced mixtures can have additional advantages for reaching quantum magnetism. We point out that at half-filling with a finite value of hopping imbalance the system has additional signatures (e.g., charge-density wave) of Neel (magnetic) ordering. We also consider additional population imbalance and study transitions between different magnetic phases in this case.

Q 51.3 Thu 14:30 V47.02

Quantum Simulation of Frustrated Quantum Ising models with cold ion crystals — •Alejandro Bermudez[1], Javier Almeida[1], Ferdinand Schmidt-Kaler[2], Alex Retzker[1], and Martin Plenio[1] — [1]Institut fur Theoretische Physik, Albert-Einstein Allee 11, Universita *t Ulm, 89069 Ulm, Germany — [2]Institut fur Physik, Staudingerweg 7, Johannes Gutenberg-Universita *t Mainz, 55099 Mainz, Germany

In this talk, I will describe how to exploit the geometry of cold-ion crystals to build a quantum simulator capable of exploring the interplay between magnetic frustration and long-ranged interactions. By modifying the anisotropy of the trapping frequencies, a number of ladder compounds can be synthetized, which give access to different frustrated quantum Ising models. I will pay special attention to the so-called zigzag ladder, which yields a neat realization of a paradigm of quantum frustration: the J1-J2 quantum Ising model [1]. I will discuss how the ordered phases are modified by the presence of the dipolar range of interactions typical of trapped-ion setups.

[1] A. Bermudez, J. Almeida, F. Schmidt-Kaler, A. Retzker, and M. B. Plenio, Phys. Rev. Lett. 107, 207209 (2011).

Q 51.4 Thu 14:45 V47.02

Electronically excited cold ion crystals — •Weibin Li and Igor Lesanovsky — School of Physics and Astronomy, The University of Nottingham, Nottingham NG7 2RD, UK

The laser excitation of an ion crystal to high lying and long-lived electronic states is a genuine many-body process even if in fact only a single ion is excited. This is a direct manifestation of the strong coupling between internal and external dynamics and becomes most apparent in the vicinity of a structural phase transition. Here we show that utilizing highly excited states offers a new approach to the coherent manipulation of ion crystals. This opens up a new route towards the creation of non-classical motional states in a Paul trap and permits the study of quantum phenomena that rely on a strong coupling between electronic and vibrational dynamics.

Q 51.5 Thu 15:00 V47.02

A bosonic Josephson junction controlled by a single trapped ion — •Rene Gerritsma[1], Antonio Negretti[2], Hauke Doerk[3], Zbigniew Idziaszek[4], Tomasso Calarco[2], and Ferdinand Schmidt-Kaler[1] — [1]Quantum, Institut für Physik, Johannes Gutenberg Universität, Mainz — [2]Institut für Quanteninformationsverarbeitung, Universität Ulm — [3]Max-Planck-Institut für Plasmaphysik, Garching — [4]Faculty of Physics, University of Warsaw, Poland

We theoretically investigate the properties of a double-well bosonic Josephson junction coupled to a single trapped ion. We find that the coupling between the wells can be controlled by the internal state of the ion, which can be used for studying mesoscopic entanglement between the two systems and to measure their interaction with high precision. As a particular example we consider a small ^{87}Rb Bose-Einstein condensate controlled by a single ^{171}Yb^{+} ion. We calculate interwell coupling rates reaching 100 Hz, while the state dependence amounts to 10s of Hz for plausible values of the currently unknown s-wave scattering length between the atom and the ion. The system could be realized in an experiment by combining trapped ions with optical dipole traps for cold atoms or in a combined atom-ion micro trap, where both approaches are within reach using current technology.

Q 51.6 Thu 15:15 V47.02

Sympathetic cooling of ions to ultralow energies — •Artjom Krükow, Andreas Brunner, Arne Härter, Stefan Schmid, Wolfgang Schnitzler, and Johannes Hecker Denschlag — Institut für Quantenmaterie, Universität Ulm, Albert-Einstein Allee 45, 89081 Ulm, Germany

We investigate the interaction of a laser-cooled trapped ion (^{138}Ba^{+} or ^{87}Rb^{+}) with an ultracold cloud of optically confined ^{87}Rb atoms. The ion is held in a linear Paul trap and is immersed in the center of the cold atomic cloud. The atom-ion interaction gives rise to a long range attractive $\frac{1}{r^4}$ polarization potential. Charge transfer processes and elastic scattering were observed at millikelvin collision energies [1,2]. The collision energy scale is given by the effect of stray electric fields on ions in a dynamic Paul trap, namely causing ion micromotion [3]. Using field compensation techniques, we achieve sympathetic cooling of the ion to Ba^{+} sub-Doppler temperatures (<300 μK) and examine the influence of ion micromotion energy over a wide range. By decreasing the ion temperatures even further we are aiming at novel experiments, such as the creation of mesoscopic atom-ion bound states [4] or the production of ultracold, charged molecules in a well-defined quantum state.

[1] S. Schmid et al, Phys. Rev. Lett. **105**, 133202 (2010)
[2] C. Zipkes et al, Phys. Rev. Lett. **105**, 133201 (2010)
[3] D. Berkeland et al, J. Appl. Phys. **83**, 10 (1998)
[4] R. Côté et al., Phys. Rev. Lett. **89**, 093001 (2002)

Q 51.7 Thu 15:30 V47.02

Scattering of ultracold atoms by a single nanowire — •Martin Fink[1], Johannes Eiglsperger[2], Javier Madroñero[1], and Harald Friedrich[1] — [1]Technische Universität München — [2]Universität Regensburg

In view of the intense attention currently given to hybrid quantum systems containing atoms at low temperatures and nanostructures, we study the dynamics of a fundamental quasi two-dimensional system consisting of an ultracold atom and a conducting nanowire of infinite length. A thorough understanding of this system is a first step towards the understanding of more complex setups involving, e.g., nanogratings that are used in diffraction experiments with atoms or large molecules. The seemingly simple atom-wire system is highly nontrivial as the interaction potential does not have a simple analytical structure, and scattering theory in two dimensions differs significantly from the well-studied three-dimensional case. Based on the full Casimir-Polder potential, we formulate an approximation that enables the numerical determination of this potential to any desired accuracy. Various scattering properties, e.g. scattering length, elastic and absorption cross section, are calculated and their characteristic behavior is discussed. We draw our attention to possible experimental realizations.

Q 51.8 Thu 15:45 V47.02

Precise radio-frequency spectroscopy of weakly bound Li-6 molecules with trap-sideband resolution — •Andre Wenz[1,2], Gerhard Zuern[1,2], Friedhelm Serwane[1,2], Thomas Lompe[1,2] und Selim Jochim[1,2] — [1]Physikalisches Institut, Universität Heidelberg — [2]Max-Planck-Institut für Kernphysik, Heidelberg

A precise knowledge of the ultracold scattering parameters is vital for most measurements performed with ultracold gases. The position of the Feshbach resonance for example is the main source of uncertainty for the determination of the Bertsch parameter. This parameter, which is universal for every strongly interacting fermionic system, rescales the energy of a resonantly interacting Fermi gas onto a non-interacting one. Its experimental determination strongly relies on the exact position of the Feshbach resonance.

We report on a measurement of the binding energy of a weakly bound molecular state in fermionic Li-6 with an improved accuracy utilizing radio-frequency spectroscopy with resolved trap-sideband resolution. The average error is reduced by more than a factor of 15 compared to previous measurements [Bartenstein et al., PRL 94,103201 (2005)]. This allows to determine the position of the Feshbach Resonance with significantly improved accuracy.